RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA,

VOLUME LXI.

Published by order of the Government of India.

CALCUTTA: GOVERNMENT OF INDIA
CENTRAL PUBLICATION BRANCH
1929

CONTENTS.

PART 1.

PART 2.

PART 3.

PART 3—*continued.*

PART 4.

LIST OF PLATES, VOLUME LXI.

PLATE 1.—*Actinodon risinensis*, sp. nov. Upper surface of the skull as drawn from the impression, natural size. The broken line indicates restored portions. Sq.=Squamosal; Au.=auditory notch; Pa.=parietal; P. f.=parietal foramen; Fr.=frontal; Orb.=orbit; Na.=nasal; Nar.=narial aperture.

PLATE 2.—View of the Jutana Cañon from the head of the 'falls'.
The laminated beds which cap the hill on the right of the picture are the flags and shales of the Salt Pseudomorph zone. The massive beds down to the rock face at the top of the scree are the Jutana Dolomites. Below these beds come the laminated horizon, seen in the next slope outward, of the Neobolus beds of Khusak Fort. They are as thick as the Jutana series. Below them, and beginning about the middle of the further slope, are the Purple Sandstones. These sandstones are underlaid by the Purple Shales which are seen in the base of the cliff near the curve of the stream bed. The section from the top of the Jutana Dolomite to the lowest point of the Purple Shales is roughly 800 feet. The total height of the point facing Jutana is upwards of 1,000 feet. The capping is of the Salt Pseudomorph beds. The base is of scree and hidden beneath this debris is the bright red marl of the Saline series of Khewra. The entrance to the cañon would be an excellent place to prove the strata beneath by boring.

PLATE 3. Panorama. View of Khewra Gorge and village.
The cliffs on each side of the gorge are capped by Dolomite (Magnesian Sandstone), and underlaid by the Neobolus Beds, which in turn overlie the Purple Sandstone and Shales. The village is situated on the Salt Marl. The rocks seen in the distance at the head of the gorge are the Nummulitic limestones. The line of subsidence extends horizontally in the picture from the bend of the stream to the entrance of the high level tunnel. The flume can be seen on the east bank of the stream. The infiltration gallery in the stream-bed had only just been started when the photograph was taken. Minor subsidences are evident in the building on the bank of the tributary stream to the right of the salt train. The entrance to the high level tunnel is above this building. The low level tunnel is under the tributary stream-bed at a depth of about 40 to 45 feet.

PLATE 4.—View looking west from the east side of the Khewra glen. Hill "1817" is seen on the left. In the middle of the picture the Salt Marl with outcrops of rock salt and included lenticles of gypsum is seen to strike westward to the Dandot valley. A close examination of this photograph will reveal the overfolded condition of the Salt Marl. It will be also evident that the overfold is more suggestive of an extrusive origin than it is of any other explanation, especially as the strata on each side—the Purple Sandstone, etc.—are never found to be bent or buckled although they are tilted and fractured. The explanation is given in Fig. 6, with which Fig. 7 should also be studied. The mining village of Tobra is seen on the right of the picture on the heights which overlook the Salt Marl.

PLATE 9.—A continuation of the Dandot section seen in Plate 8, and also taken from Hill "2061" looking eastward. The inverted Cambrian beds—the gypsum band at the base of the Purple Shales, the Purple Sandstones and particularly the junction between the Purple Sandstone and the Neobolus Beds, are all clearly seen. The sunken mass of Cambrian strata embedded in the Salt Marl across the valley is also evident (see Plate 10).

PLATE 10.—Is a view looking east-south-east from the saddle, between Hill "2340" and Dandot village, at top of incline. Hill 1817 with its cap of Magnesian Sandstone is seen in the distance with the Jhelum river beyond. The belt of Salt Marl and rock-salt outcrops which trend into the Khewra glen is seen in the middle of the picture. The sunken mass of Neobolus Beds with a capping of Magnesian Sandstone and a plinth of Purple Sandstone is seen, surrounded by the bright red Salt Marl, just above the post of the distant signal. The tubs are filled with limestone (4) and coal (2). On the left of the picture the Cambrian strata are seen *in situ* on the main cliff face.

PLATE 11.—This is a view from below the summit of Hill "2340" south of Dandot looking westward to Hill "2061" and the Jhelum river beyond. The gypsum band G is clearly seen to be conformable to the underlying strata. In the foreground are seen the Salt Pseudomorph Beds. The man on the right is standing in front of the little cliff which is the base of the Boulder Bed. The glen below is the Uchli Kas Kurlnia lies at the entrance to the gorge, seen on the left of the picture, which leads up into the Uchli Kas. Salt Marl is seen in the foot-hills on the left. The dark rocks seen at the bottom left-hand corner are inverted Purple Sandstones. The strata lying in a normal position are seen on the spur which joins Hill "2061" with the foot of the Dandot scarp to the north (right).

PLATE 12.—Banded rock-salt in the Nilawan Ravine. Tilted, faulted and squeezed strata of the Saline Series which suggest tectonic movements in the Salt Range. The mass is really partly slipped and partly up-heaved material. The whole appears to have subsided as the result of the solution and wetting of the soft clayey material of the Saline Series. The pressure of the strata of the main slope has squeezed out the plastic salt and saline marl under and into the ravine bed. Looked at closely it will be seen that the section across the ravine is that of a low anticline, the tilt away from the gorge being due to the pushing out, upward, of the plastic, wetted marl and rock-salt of the Saline Series. The cutting action of the stream disturbs the isostatic balance by removing material from over the plastic beds, and this, as a result of the pressure of the strata on the main hills on either side, has pushed up into the ravine floor.

PLATE 13.—View looking up the Nilawan Ravine. The Saline Series of rock-salt, gypsum and bright red saline marls, are seen on the right bank of the picture. These strata are overlaid by the shales of the Khewra stage (Purple Sandstone) and then by the sandstone. The spur at the right top is capped by the Kusak (Neobolus) Shales while the main scarp to which this spur is joined is capped with the Jutana Dolomite (Magnesian Sandstone). A gentle anticlinal structure across the valley is fairly evident the dips being somewhat steeper in the lower beds in the sides of the ravine as though the valley floor corresponded with an axis of bending due to the localized pressure of some underground heave.

PLATE 14.—View looking back (south) down the Nilawan Ravine. The pinnacle on the left is Purple Sandstone (Khewra stage) underlaid by purple shales with the Saline Series showing in the base of the slope in the ravine. The massive Purple Sandstone is seen forming the plinth of the bluff in the middle of the picture. The overlying soft beds are the Kusak

PLATE 25.—FIG 2.—Photomicrograph of the Lua meteorite showing an idiomorphic crystal of olivine in a polysomatic chondrus of olivine and also other chondri of olivine.

PLATE 26.—Erratic blocks resting on Triassic limestone near Bura.

PLATE 27.—FIGS. 1 to 8.—*Orbitolina tibetica* n. sp., magnified 3·66 times. Figs. 3 and 7 are flat forms; fig. 4 is the most conical; figs. 1, 2, 5, 6, and 8 are moderately conical forms. In figs. 2, 4 and 6 the external ornamentation is well preserved.

„ 9, 10.—*Orbitolina tibetica* n. sp.; discoidal forms showing concentric lamellæ and central boss. Magnified 18 times.

„ 11.—Vertical section through two specimens of *O. tibetica*, which are cemented together by calcareous matrix. Magnified 13 times.

„ 12.—Vertical section through a megalospheric form. Magnified 23 times.

NOTE.—The specimens figured in figures 1 to 11 are from Kyatsok; that shown in figure 12 is from Lhundub Dzong

PLATE 28.—FIG. 1.—*Orbitolina tibetica* n. sp. Specimen etched with dilute HCl, to expose the concentric lamellæ. Magnified 34 times.

„ 2.—Horizontal section through another specimen in a latitude below the region of rectangular cells. In this the lower portions of the rectangular cells are seen to have roughly triangular or irregular outlines. Magnified 23 times.

„ 3.—Vertical section through a discoidal specimen of *O. tibetica* not traversing the central boss. Magnified 13 times.

„ 4.—Horizontal section through another specimen of *O. tibetica* at a lower latitude than that of fig. 2. Magnified 23 times.

„ 5.—Oblique section through a megalospheric form of a moderately conical type. Magnified 13 times

NOTE.—All the specimens are from Kyatsok.

PLATE 29.—Map of the Joya Mair Dome Fold. Scale 1 inch = 1 mile.

Section across the Joya Mair Dome Fold along the line A B. Scale 1 inch = 1 mile, horizontal and vertical.

MGIPC—M—VIII-4-14—27-4-29—800.

Records Vol. LX, part 4, will be issued later.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 1] 1928. [May

GENERAL REPORT FOR 1927. BY SIR EDWIN PASCOE, M.A., SC.D. (CANTAB.), D.SC. (LOND.), F.G.S., F.A.S.B., *Director, Geological Survey of India.*

DISPOSITION LIST.

DURING the period under report the officers of the Department were employed as follows :—

Superintendents.

DR L. L. FERMOR . Placed in charge of office till the 19th April. Acted as Palæontologist from the 6th April to the 31st July 1927. Placed in charge of the Central Provinces and Central India Party and also temporarily of the Bihar and Orissa Party.

DR. G. E. PILGRIM . Acted as Palæontologist till the 5th April 1927. Left for the field on the 3rd April 1927 and returned on the 20th July 1927. Remained at headquarters and acted as Palæontologist from the 1st August 1927.

MR. G. H. TIPPER . Returned from the field on the 25th February 1927. Granted combined leave for two years and four months with effect from the 6th May 1927, and permitted to retire on the expiry of leave.

DR. G. DE P. COTTER . Returned from the field on the 14th March 1927. Granted combined leave for eight months from the 28th March 1927. Returned from leave on the 16th November 1927. Placed in charge of the Punjab Party; left for the field on the 23rd November 1927.

DR. J. COGGIN BROWN . Granted leave on average pay for seven months and twenty-five days with effect from the 1st April 1927. Returned from leave on the 7th November 1927; placed in charge of the Burma Party.

MR. H. CECIL JONES . Returned from the field on the 9th April 1927. Granted combined leave for ten months and seven days with effect from the 6th May 1927. Permitted to attend the meeting of the Second Empire Mining and Metallurgical Congress held in Canada in August 1927.

Assistant Superintendents.

MR. H. WALKER . . Retired from service with effect from the 16th March 1927.

DR. A. M. HERON . Returned from the field on the 3rd February 1927. Granted Study leave for nine months with effect from the 12th February 1927. Returned from leave on the 7th November 1927. Placed in charge of the Rajputana Party and left for the field on the 21st November 1927.

DR. C. S. FOX . .	Returned from the field on the 9th June 1927. Left for the Giridih coalfield on the 12th July and returned to headquarters on the 16th. Placed in charge of the Coalfields Party. Left for the field on the 1st October 1927.
MR. H. CROOKSHANK .	Granted leave on average pay for six months and eleven days; availed himself of the same with effect from the 13th April 1927 from the field. Returned from leave on the 22nd October 1927. Attached to the Central Provinces and Central India Party and left for the field on the 7th November 1927.
MR. G. V. HOBSON .	Returned from leave on the 6th November 1927. Attached to the Coalfields Party and left for the field on the 23rd November 1927.
MR. E. L. G. CLEGG .	Acted as Curator of the Geological Museum and Laboratory till the 19th April 1927. Placed in charge of office from the 20th April 1927.
RAO BAHADUR S. SETHU RAMA RAU.	Returned from the field on the 1st May 1927. Attached to the Coalfields Party. Left for the field on the 15th November 1927.
RAO BAHADUR M. VINAYAK RAO.	Returned from the field on the 5th May 1927. Detailed for the investigation of the manganese occurrences in the Belgaum and Kanara districts of the Bombay Presidency and thereafter for the continuance of the survey of the North Arcot and Salem districts in the Madras Presidency. Left for the field on the 1st November 1927.

MR. E. J. BRADSHAW .	Attached to the Burma Party; remained in Burma throughout the period. Placed temporarily in charge of the Party during the absence of Dr. Coggin Brown on leave.
MR. A. L. COULSON .	Returned from the field on the 15th April 1927. Acted as Curator of the Geological Museum and Laboratory from the 20th April to 31st August 1927. Detailed for the investigation of the hill slopes around Naini Tal. Left for the field on the 3rd September and returned to headquarters on the 10th October 1927. Appointed Curator of the Geological Museum and Laboratory from the 12th October 1927.
MR. D. N. WADIA .	Returned from leave on the 3rd November 1927. Attached to the Punjab Party; left for the field on the 18th November 1927.
DR. J. A. DUNN . .	Returned from the field on the 21st April 1927. Attached to the Bihar and Orissa Party. Left for the field on the 30th October 1927.
MR. C. T. BARBER. .	Remained in Burma throughout the period as Resident Geologist at Yenangyaung and official member of the Yenangyaung Advisory Board.
MR. E. R. GEE . .	Returned from the field on the 14th March 1927. Granted combined leave for seven months and twenty-four days with effect from the 18th March 1927. Returned from leave on the 22nd October 1927. Attached to the Coalfields Party; left for the field on the 1st November 1927.

MR. W. D. WEST . . Returned from the field on the 11th July 1927. Remained at headquarters during the rest of the period under report.

MR. A. K. BANERJI . Returned from the field on the 7th May 1927. Acted as Curator of the Geological Museum and Laboratory from the 1st September to the 11th October 1927. Attached to the Coalfields Party; left for the field on the 1st November 1927.

DR. M. S. KRISHNAN . Returned from the field on the 4th May 1927. Services placed at the disposal of the Department of Education, Health and Lands for a period of four months with effect from the 1st July 1927. Attached to the Bihar and Orissa Party; left for the field on the 15th November 1927.

MR. P. LEICESTER . Attached to the Burma Party; remained in Burma throughout the period under report.

DR. S. K. CHATTERJEE . Returned from the field on the 29th April 1927. Granted leave on average pay for twenty-four days with effect from the 4th May 1927. Returned from leave on the 28th May 1927. Attached to the Central Provinces and Central India Party; left for the field on the 7th November 1927.

MR. J. B. AUDEN . . Returned from the field on the 13th April 1927. Attached to the Coalfields Party; left for the field on the 3rd November 1927.

MR. V. P. SONDHI . Attached to the Burma Party; remained in Burma throughout the period under report.

MR. B. B. GUPTA . . Appointed Assistant Superintendent, Geological Survey of India, with effect from the 1st November 1927. Attached to the Burma Party.

Chemist.

DR. W. A. K. CHRISTIE . At headquarters.

Artist.

MR. K. F. WATKINSON . At headquarters till the 10th July 1927. Granted leave on average pay for two months and fifteen days with effect from the 11th July 1927. Returned from leave on the 26th September 1927. Remained at headquarters during the rest of the period under report.

Sub-Assistants.

MR. B. B. GUPTA . . Attached to the Burma Party. Promoted to the grade of Assistant Superintendent with effect from the 1st November 1927.

MR. D. S. BHATTACHARJI. Returned to headquarters from field work in the Central Provinces on the 6th May 1927. Attached to the Central Provinces and Central India Party; left for the field on the 10th November 1927.

MR. B. C. GUPTA .	Returned to headquarters from field work in Rajputana on the 2nd May 1927. Granted leave on average pay for eighteen days with effect from the 12th September 1927 and permitted to affix the Puja holidays. Returned from leave on the 12th October 1927. Attached to the Rajputana Party; left for the field on the 17th November 1927.
MR. H. M. LAHIRI .	Returned from field work in the Punjab on the 1st May 1927. Granted leave on average pay for three months and eleven days with effect from the 4th May 1927. Returned from leave on the 1st August 1927. Attached to the Punjab Party; left for the field on the 1st December 1927.
MR. L. A. NARAYANA IYER.	Returned from field work in Bihar and Orissa on the 4th April 1927. Granted leave on average pay for two months and seven days with effect from the 6th April 1927. Returned from leave on the 13th June 1927. Granted combined leave for two years with effect from the 12th September 1927.
MR. P. N. MUKERJEE .	At headquarters till the 11th October 1927. Granted leave on average pay for seven weeks with effect from the 12th October 1927. Returned from leave on the 30th November 1927. Remained at headquarters

Assistant Curator.

MR. P. C. ROY . .	At headquarters.

Field Collectors.

N. K. N. AIYENGAR .	Returned to headquarters after collection of specimens from the Punjab and Rajputana on the 21st April 1927. Granted leave on average pay for two months with effect from the 16th May 1927. Remained at headquarters.
A. K. DEY . .	Returned to headquarters after collection of specimens from Madras on the 17th May 1927. Detailed for the collection of specimens in Bombay. Left for the field on the 22nd November 1927.

Museum Assistants.

AUSTIN. M. N. GHOSH.	At headquarters.
D. GUPTA . .	At Headquarters till the 11th October 1927. Granted leave on average pay for one month and twenty-eight days with effect from the 12th October 1927. Returned from leave on the 10th December 1927. Remained at headquarters.

The cadre of the Department continued to be 6 Superintendents, 22 Assistant Superintendents and one Chemist. Of the two vacancies in the grade of Assistant Superintendent, including the one caused by the retirement on pension of Mr. H. Walker, one was filled during the year.

ADMINISTRATIVE CHANGES.

Promotion and appointments.

Dr. C. S. Fox was appointed to officiate as Superintendent from the 28th March 1927 to the 15th November 1927 *vice* Dr. G. de P. Cotter on leave, and again from the 16th November 1927 onwards *vice* Mr. H. C. Jones on leave.

Dr. Heron was appointed to officiate as Superintendent from the 7th November 1927 *vice* Mr. G. H. Tipper on leave.

Mr. E. L. G. Clegg was appointed to officiate as Superintendent from the 20th April to the 6th November 1927 *vice* Dr. J. Coggin Brown on leave and again from the 7th to the 15th November 1927 *vice* Mr. H. C. Jones on leave.

Mr. E. L. G. Clegg acted as Curator, Geological Museum and Laboratory till the 19th April 1927. Mr. A. L. Coulson acted as Curator till the 31st August 1927, when his duties were taken over by Mr. A. K. Banerji. The latter officer was relieved by Mr. A. L. Coulson on the 12th October 1927.

Dr. G. E. Pilgrim acted as Palæontologist till the 5th April 1927 when he was relieved by Dr. L. L. Fermor. From the 1st August 1927 Dr. Pilgrim again acted as Palæontologist.

Mr. P. Leicester and Dr. S. K. Chatterjee have been confirmed in their appointments as Assistant Superintendents.

Mr. B. B. Gupta, Sub-Assistant, was promoted Assistant Superintendent with effect from the 1st November 1927.

Retirement.

Mr. H. Walker, Assistant Superintendent, retired from the service with effect from the 16th March 1927.

Leave.

Mr. G. H. Tipper was granted combined leave for two years and four months with effect from the 6th May 1927.

Dr. G. de P. Cotter was granted combined leave for eight months with effect from the 28th March 1927.

Dr. J. Coggin Brown was granted leave on average pay for seven months and twenty-five days with effect from the 1st April 1927.

Mr. H. Cecil Jones was granted combined leave for ten months and seven days with effect from the 6th May 1927.

Dr. A. M. Heron was granted study leave for nine months with effect from the 12th February 1927.

Mr. H. Crookshank was granted leave on average pay for six months and eleven days with effect from the 13th April 1927.

Mr. G. V. Hobson was granted an extension of leave for thirty-five days with effect from the 7th October 1927.

Mr. E. R. Gee was granted combined leave for seven months and twenty-four days with effect from the 18th March 1927.

Dr. S. K. Chatterjee was granted leave on average pay for twenty-four days with effect from the 4th May 1927.

Mr. K. F. Watkinson was granted leave on average pay for two months and fifteen days with effect from the 11th July 1927.

Mr. B. C. Gupta was granted leave on average pay for eighteen days with effect from the 12th September 1927.

Mr. H. M. Lahiri was granted leave on average pay for three months and eleven days with effect from the 4th May 1927.

Mr. L. A. Narayana Iyer was granted leave on average pay for two months and seven days with effect from the 6th April 1927 and was again granted combined leave for two years with effect from the 12th September 1927.

Mr. P. N. Mukerjee was granted leave on average pay for seven weeks with effect from the 12th October 1927.

LECTURESHIP.

Mr. E. L. G. Clegg continued as Lecturer on Geology at the Presidency College, Calcutta, till the 31st October 1927 when he was relieved by Mr. A. L. Coulson. Dr. M. S. Krishnan acted as a wholetime lecturer on Geology at the Forest College, Dehra Dun, for a period of four months from 1st July 1927.

POPULAR LECTURES.

A popular lecture on "A Geological Excursion to the Canary Islands" was delivered in the Indian Museum by Dr. L. L. Fermor during the year.

LIBRARY.

The additions to the Library amounted to 4,628 volumes of which 1,215 were acquired by purchase and 3,413 by presentation and exchange.

PUBLICATIONS.

The following publications were issued during the year under report :—

1. Records, Vol. LIX, part 4.
2. Records, Vol. LX, part 1.

3. Records, Vol. LX, part 2.
4. Records, Vol. LX, part 3.
5. Palæontologia Indica, New Series, Vol. VII, Memoir No. 3.
6. Palæontologia Indica, New Series, Vol. IX, Memoir No. 2, Part I.
7. Palæontologia Indica, New Series, Vol. X, Memoir No. 1.
8. Palæontologia Indica, New Series, Vol. X, Memoir No. 2.
9. Palæontologia Indica, New Series, Vol. XIV.

MUSEUM AND LABORATORY.

Staff.

Mr. E. L. G. Clegg was Curator of the Geological Museum and Laboratory from the beginning of the year under report until the 19th April. On the 20th April he was relieved by Mr. A. L. Coulson who remained in charge until 31st August. Mr. A. K. Banerji assumed the duties from the 1st September to 11th October and from the 12th October Mr. A. L. Coulson again resumed charge. Babu Purna Chandra Roy remained Assistant Curator throughout the year and Babus Austin Manindra Nath Ghosh and Dasarathi Gupta fulfilled the duties of Museum Assistants. During the absence of Babu Dasarathi Gupta on leave, his duties were temporarily performed by Babu Nabagopal Gupta. Babu Lekh Raj continued to act as Chemical Assistant to the Burma Party, Rangoon.

Chemist.

After his return from leave on the 2nd January, Dr. W. A. K. Christie continued his duties as Chemist throughout the year, remaining at headquarters for the whole period.

Determinative Work and Analyses.

The number of specimens referred to the Curator for examination and report was 676 of which assays and analyses were made of 46. The corresponding figures for the previous year were 396 and 53, respectively. Chemical work included analyses of gases, waters, coals, limestones, manganese ores, sillimanite-rocks, pyrrhotite, gedrite, juddite, gneiss, calc-gneiss and quartz-magnetite-rock.

Beads from Mohenjo Daro, Sind.

A collection of 150 well-preserved beautiful beads—not included in the above figures—was submitted for examination by the Archæological Survey of India. These were found during recent excavation work at Mohenjo Daro, in Sind, and are considered to be be-

tween 4,500 and 5,000 years old. The skill of the lapidary shown in the making of the beads so as to bring out their full beauty indicates a surprisingly advanced state of cultural development. The beads are mostly of agate, agate-jasper, jasper, onyx, bloodstone, amazon stone, chalcedony and jade. The writer is preparing for the Archæological Survey a note upon the sources of the minerals found at Mohenjo Daro.

Gahnite.

A specimen from near Jogipalli Shrotriem (14° 13′: 79° 44′) in the Madras Presidency has been identified as one of the gahnite group of zinc-spinels, a group of very uncommon occurrence in India.

Number of specimens in the Museum collections.

During the year, an inventory was taken of the number of specimens exhibited and stored in the collections of the Geological Survey of India. The following figures are of interest :—

—	Total Number.	Number exhibited in the Museum.
Minerals interesting from a scientific point of view.	11,960	4,220
Minerals interesting from an economic point of view.	4,690	4,690
Meteorites	588	588
Rocks	44,160	3,730
Fossils—Vertebrate	26,780	3,270
Fossils—Invertebrate	197,270	47,890
Duplicate rocks and minerals arranged in sets for educational purposes.	14,950	..
TOTALS .	300,398	64,388

Donations to Museums, etc.

During the year under review, collections of minerals were presented to the under-mentioned institutions :—

1. Department of Commerce, University of Allahabad.
2. Department of Botany, St. John's College, Agra.
3. Mineral Department, British Museum (Natural History).

4. Geological Survey of South Africa.
5. University of Calcutta.
6. Agricultural College, Lyallpur.

In addition to the above, the following specific presentations were made :—

1. Corundum to T. V. M. Rao, Esq., Geology Department, Imperial College of Science and Technology, London.
2. Talchir boulders to Prof. E. W. Skeats, University of Melbourne.
3. Glass-making materials to the Principal, Technological Institute, Cawnpore.
4. Bauxite to J. K. Chaudhury, Esq., Reader of Chemistry, Dacca University.
5. Tourmaline to the Indian Institute of Science, Bangalore.

Additions to Collections.

In addition to a large number of specimens collected by members of the Department, the following specimens were received and included in our collections :—

1. Raw coal, dried coal and a briquette, Yallourn, Australia. Presented by Diwan Bahadur T. Rangachariar, C.I.E.
2. Allachite, Sweden. Presented by Prof. P. Quensel.
3. Nasonite, Sweden. Presented by Prof. P. Quensel.
4. Finnemanite, Sweden. Presented by Prof. Quensel.
5. Dixenite with pyro-aurite, Sweden. Presented by Prof. P. Quensel.
6. Sarkinite, Sweden. Presented by Prof. P. Quensel.
7. Magneto-plumbite, Sweden. Presented by Prof. P. Quensel.
8. Langbanite, Sweden. Presented by Prof. P. Quensel.
9. Quenselite, Sweden. Presented by Prof. P. Quensel.
10. Hausmannite, Sweden. Presented by Prof. P. Quensel.
11. Braunite crystal, Sweden. Presented by Prof. P. Quensel.
12. Corundum crystal. Presented by the Director, Geological Survey of South Africa.
13. Chrome-garnet (uvarovite). Presented by the Director, Geological Survey of South Africa.
14. Hortonolite-dunite (a platinum-bearing rock), Lydenburg district, Transvaal. Presented by the Director, Geological Survey of South Africa.

15. Hortonolite-dunite in contact with chromite-rock. Same locality. Presented by the Director, Geological Survey of South Africa.
16. Volcanic ash, from Mt. Pelée, Martinique, West Indies. Presented by M. E. Gaudert, Pondicherry.
17. Garnet crystal in mica. Purchased.
18. Chapmanite, Ontario. Presented by Dr. T. L. Walker.
19. Collinsite, British Columbia. Presented by Dr. T. L. Walker.

Meteorites.

No falls of meteorites were recorded during the year under review. On the 28th November, however, a very fine specimen of a stone meteorite, weighing 8,632 grammes, was received for examination from the Mewar Durbar, Rajputana. This fell in the village of Lua (24° 57′ : 75° 11′), Begu *pargana* of the Udaipur State, between 3 and 3-30 o'clock, p.m., on the 26th June 1926 and was mentioned in the preceding General Report. A complete account of the stone will be published later.

Burma Laboratory.

During 1927 in the Burma Laboratory 114 specimens were received and reported on, of which 18 were quantitatively examined. The corresponding figures for 1926 were 98 and 13 respectively. The specimens examined included ancient ornaments and jewellery found by the Archæological Survey during the course of excavations at Hmawza (Old Prome); coal, iron ore, lead ore, tin ore and stibnite.

DRAWING OFFICE.

The artist, Mr. K. F. Watkinson, remained in charge throughout the year, with the exception of two-and-a-half months when Babu Kali Dhan Chandra held charge.

Publications.

The amount of publication work passing through the Drawing Office has been steadily maintained, a noticeable feature of the work submitted for reproduction being the intricacy of the geological detail. The following plates have been prepared during the year: 21 plates for the Records, 37 plates for the Memoirs and 23 plates for the Palæontologia Indica.

The total number of impressions made for publication were 54,750. This work has involved the preparation of 206 separate fossil photographs and 265 separate fossil drawings.

The plates for two volumes of the Memoirs are ready for publication and plates for two more are in course of preparation.

Geological Map of India.

The preparation of the new geological map of India, scale 1 inch =32 miles, has not proceeded as rapidly as anticipated. Minor alterations to the geology and a modification in the method of reproduction have delayed the draftsmen, but the work is proceeding steadily.

Map section.

The card index catalogue of original geological maps has been finished and brought into use. Work on the reduction of the one-inch-to-the-mile surveys to the quarter-inch scale has proceeded slowly, 36 one-inch sheets having been finished. Coloured original maps are mounted on cloth when stored, and the repair of old and damaged maps provides constant work.

Photographic section.

The photographic section has been kept fully occupied both in the preparation of prints to illustrate officers' reports, and in the preparation of blocks for printing. The number of negatives registered and added to the collection during the year was 242 against 332 in 1926. The number of photographic prints made amounted to 1,344 against 1,676 in 1926.

PALÆONTOLOGY.

Dr. G. E. Pilgrim continued to fill the post of Palæontologist up to the 5th April and again from the 1st August for the remainder of the year. Between the 6th April and the 31st July Dr. L. L. Fermor took charge during Dr. Pilgrim's absence in the Simla Hills. Sub-Assistant P. N. Mukherjee assisted the Palæontologist with routine Museum work and with the determination of specimens during the year with the exception of two-and-a-half months absence on leave. Museum Assistant A. M. Ghosh has been engaged under Dr. Pilgrim's supervision during most of the year in arranging, cataloguing and preparing a card index of the specimens in the Fossil Vertebrate gallery. A card index of the invertebrate collections is also being compiled.

During the year under review the following memoirs have been published in the *Palæontologia Indica* :—

(1) E. Vredenburg: "A Review of the Genus Gisortia with descriptions of several species." Memoir No. 3 of Vol. VII of the New Series.

(2) L. F. Spath: "Revision of the Jurassic Cephalopod fauna of Kachh." Part I of Memoir No. 2, Vol. IX of the New Series.

(3) F. R. C. Reed: "The Palæozoic and Mesozoic fossils from Yunnan." Memoir No. I of Vol. X of the New Series.

(4) M. Cossmann and G. Pissarro: "The Mollusca of the Ranikot Series (together with some species from the Cardita Beaumonti Beds) revised by the late E. Vredenburg, with an introduction and editorial notes by G. de P. Cotter. Memoir No. 2 of Vol. X of the New Series.

(5) G. E. Pilgrim: "A Sivapithecus palate and other Primate fossils from India." Vol. XIV of the New Series.

The following papers of palæontological interest have appeared in the Records:—

(1) "The Distribution of the Gault in India," by G. de P. Cotter. (Vol. LIX, pt. 4.)

(2) "The Age of the so-called Danian fauna from Tibet," by G. de P. Cotter. (Vol. LIX, pt. 4.)

(3) "On some fossil Indian Unionidæ," by B. Prashad. (Vol. LX, pt. 3.)

(4) "The Lower Canine of Tetraconodon", by G. E. Pilgrim. (Vol. LX, pt. 2.)

The following papers of palæontological interest have not been published this year but print-off orders have been issued for all of them, and they are expected to be published early in 1928.

Memoirs in the *Palæontologia Indica*:—

(1) L. F. Spath: "Revision of the Jurassic Cephalopod fauna of Kachh." Part II of Memoir No. 2, Vol. IX of the New Series.

(2) H. Douvillé: "Les Couches à Cardita Beaumonti dans le Beluchistan." Memoir No. 3, Vol. X of the New Series.

(3) E. Vredenburg: "A Supplement to the Mollusca of the Ranikot Series edited with notes by G. de P. Cotter." Memoir No. 4, Vol. X of the New Series.

(4) B. Sahni: "Revisions of Indian Fossil Plants. I. Coniferales." Vol. XI of the New Series.

(5) H. S. Bion: "The Fauna of the Agglomeratic Slate Series of Kashmir." Vol. XII of the New Series.

(6) G. E. Pilgrim : "The Artiodactyla of the Eocene of Burma." Vol. XIII of the New Series.

Paper of palæontological interest in the *Records* :—

(1) "A Permo-Carboniferous marine fauna from the Umaria Coalfield," by F. R. C. Reed (Vol. LX, pt. 4).

During a part of the year Dr. G. E. Pilgrim has been engaged in a revision of the fossil Indian Carnivora. The collections of the last 15 years have brought to light specimens which not only add to our knowledge of species created by Lydekker, but also represent new genera and species. Amongst the latter the Mellivorine group of the Mustelids are particularly well represented, though the material is unfortunately fragmentary.

Dr. L. F. Spath continues his revision of the Cephalopod fauna of Kachh, and he, as well as Miss Muir Wood and Mr. L. R. Cox, is studying the Cretaceous fossils of Gault age collected in Hazara by Mr. C. S. Middlemiss and in the Samana range of the N.-W. Frontier by Major L. M. Davies.

Sub-Assistant H. M. Lahiri has been engaged during the recess in the final preparation for the Press of the late Mr. Vredenburg's manuscripts of the second volume of the Post-Eocene Mollusca of N.W. India. His work has consisted not in the revision of the descriptions of the species but in identifying the actual specimens as far as possible (many even now have not come to light) with the figures and descriptions, inserting their localities and horizons according to Mr. Vredenburg's latest nomenclature, rectifying the more obvious inconsistencies, and supplying numerous omissions of dates, references and the like. Registration numbers have now been given not only to such specimens as have been figured in the memoir but also to those unfigured specimens belonging to species which Mr. Vredenburg recognized in the Indian deposits, and which can be traced by his hand-written labels or descriptions. The entire series is now stored amongst the Geological Survey of India type collection, and is available for reference when required. The memoir has been unavoidably delayed owing to this work, but will be issued in the course of next year.

Last season Field Collector Aiyengar collected from the Kamlial stage of the Lower Siwaliks of Sadrial, near Khaur in the Attock district,

an almost perfect mandible of a species of *Conohyus*, probably *C., sindiensis.* Of especial interest is the preservation of the base of the canine, hitherto unknown, which shows a cross-section no less strongly scrofic than that of the European species of *Conohyus*, and so entirely different from that of the other contemporary Indian pigs which have a verrucose or sub-verrucose cross-section. This mandible forms the subject of a joint note by Dr. G. E. Pilgrim and Mr. Aiyengar which will in the first instance be communicated to the Indian Science Congress in January 1927 and subsequently be published in the Records of this Department.

Dr. Baini Prashad of the Zoological Survey of India, who has been studying the fossil *Unionidæ* in the Geological Survey collections has submitted a preliminary paper containing descriptions of three new species, *Lamellidens jammuensis* and *Indonaia mittali* collected by Mr. N. C. Mittal from the supposed Upper Siwaliks of Nagrota, Jammu, Kashmir, presented by the Maharajah Bahadur of Kashmir, and *Indonaia pascoei* collected by Mr. K. A. K. Hallowes from the Lametas of Nawapet, Hyderabad. This is published in the Records, Vol. LX, part 3.

From time to time specimens of fossil plants obtained in the course of survey operations have been sent for examination to Professor B. Sahni of Lucknow University. Amongst these a fossil fruit collected by Dr. C. S. Fox from the Tipam Sandstone, 22 miles from Silchar, Cachar, Assam, has been provisionally assigned to one of the *Juglandaceæ.* Some dicotyledonous leaves from the coal measures of the Naga Hills, also collected by Dr. Fox, prove to be identical with the species *Phyllites kamarupensis* Seward (*Rec. Geol. Surv. Ind.* Vol. XLII, p. 94, 1912) from the coal seams of Margharita in Upper Assam.

Amongst the numerous specimens kindly presented to the department during the year or submitted for determination the following deserve special mention.

Major A. L. Bacon, V.D., of the Burma Ruby Mines, Ltd., presented a number of fossil bones and teeth which were found in a limestone cave on the eastern side of the Mogok valley. Since teeth of *Stegodon* occur amongst them we must conclude either that the remains are of Pleistocene age or that the genus *Stegodon* persisted into sub-Recent times. It will be remembered that from another cave in the neighbourhood of Mogok, Mr. Bacon obtained

some years ago a skull of a carnivore which Sir A. S. Woodward described and referred to a new genus to which he gave the name of *Aelureidopus.*

Another Ursoid animal, which appears to be extinct, is represented in the present collection and awaits further study. The remainder of the collection consists of fragmentary jaws of pigs, deer and antelopes, which unfortunately furnish no precise data for specific determination. It is hoped not only that further collections may be made from these caves, which promise to yield an interesting fauna, but also that the geology of the caves and the nature of the cave deposit may be investigated before long.

Mr. A. H. M. Barrington, Conservator of Forests, Hlaing Circle Burma, submitted for identification a collection of fossils from the Pegu Yoma, the precise locality being the bed of the stream half a mile above Myauknigon (19° 32′; 95° 25′). The specimens were examined by Mr. B. B. Gupta who succeeded in specifically identifying all but a very few and assigned them to the Kama stage of the late Mr. Vredenburg's scheme of classification. Two specimens (*Cyllene* cf. *C. varians*, Cossm. and a *Clavilithes* related to *C. seminudus*) are probably new species and have been retained for further examination. The remaining specimens are of previously described species and include :—*Clavilithes seminudus* Noetl., *Conus* (*Lithoconus*) *odengensis* Mart., *Surcula* (*Pleurofusia*) *phasma* Vred., *Drillia* (*Brachytoma*) *buddhaica* Vred., *Pleurotoma* cf. *ickei* Martin., *Merica promensis* Vred., *Rimella* (?) *javana* Martin, *Drillia* (*brachytoma*) *yabei* Vred., *Cidaris* spine, *Natica* (*Naticina*) aff. *blainvillei*, Desh., *Pecten kokenianus*, Noetl, *Oliva* (*Strephona*) *australis*, Duclos var. *indica* Vred., *Olivacillaria* (*Agaronia*) *pagodula* Vred., *Dione protophillippinarum* Noetl. var. *orbicularis*, and *Ostraea* sp.

Some poorly preserved fossil specimens were obtained by Mr. D. Dale Condit of the Whitehall Petroleum Corporation from the oil-bearing strata of the Naga Hills, 3 miles south-west of Nichu Guard, a point on the Kohima road, 9 miles from Manipur Road Station. The fossil bed is said to be 2 000 feet or more above a Nummulitic horizon. Sub-Assistant P. N. Mukerjee has discovered a very close affinity between a few shells in the collection and *Cyrena* (*Batissa*) *crawfurdi*, a species which characterizes the topmost beds of the Pegus at Yenangyaung, Burma. This suggests that the Naga Hill bed may be of the same age.

Another small collection of fossils from Assam in an equally bad condition has been in the hands of the Palæontologist for examination. The locality is N. W. of Kanchanpur, about 25 miles S. S. W. of Badarpur, in the Cachar district and about 4 miles W. S. W. of Hailikandi. Dr. C. S. Fox visited it with Mr. H. M. Sale of the Burmah Oil Company and collected the specimens. Amongst them Mr. P. N. Mukerjee found only two which admitted in any way of specific determination. These are two species of *Meiocardia*, of which one is closely allied to *Meiocardia metavulgaris* Noetling, while the other is new. Noetling recorded the species *M. metavulgaris* from his zones of *Mytilus nicobaricus* and of *Meiocardia metavulgaris*, both from Singu, Burma. Vredenburg correlated the Singu stage with the Upper Nari of N. W. India and, therefore, regarded it as the equivalent of the Chattian of Europe (Upper Oligocene). Since the fossils occur in considerable numbers at this site it is hoped that better preserved specimens may reach us before long, which will permit of a more satisfactory estimate of the geological age. It will be remembered that Mr. Vredenburg attempted a provisional correlation of the Tertiaries of Assam in 1921 (*Rec. Geol. Surv. Ind.* Vol. LI, pp. 330-36), but the scarcity of fossils and the difficulties of geological investigation in this densely forested region gives an exceptional interest to fossil occurrences such as the ones which have been recorded above.

A collection of fossils made by Mr. R. D. Thomson from the Agglomeratic Slate series of the Bren spur near Srinagar, Kashmir, possesses considerable interest. In the first place the specimens come from a locality, in which though the Agglomeratic Slate series has been mapped by Middlemiss and Bion, no fossils except *Fenestella* have been recorded. In the second place the species are entirely different from those which Bion has described from other exposures (*Pal. Ind.* New Ser. Vol. XII). This difference may be due to a varying local facies, or to a different age. The latter explanation would accord well with Middlemiss' view (*op. cit.* p. 12) that these beds occur at varying horizons in the different sections. The third feature of interest is that undoubted evidence of glacial action in the Agglomeratic Slate is here found for the first time in the presence of striated and facetted pebbles. Mr. Middlemiss (*op. cit.* p. 4) has already suggested a glacial origin for the Agglomeratic Slate, but was on the whole inclined to reject it in favour of explosive volcanic action. *Reticularia lineata, Martiniopsis* and other Brachiopoda

occur in Mr. Thompson's collection as well as numerous Lamellibranchiata. It is proposed to have the collection described and figured at a subsequent date.

During the early part of the field-season, Sub-Assistant L. A. Narayana Iyer, was deputed to make a further examination of the patches of Upper Gondwana rocks along the East Coast with a view to obtaining, if possible, a more representative collection of the marine element of the mixed assemblage of land plants and sea animals. The outcrops are all east of the granite boundary and covered up either by laterite or black cotton soil. Exposures are poor and sometimes limited to material from recently dug wells. The beds are very thin, and have a gentle or rolling dip. Of the four groups of exposures enumerated by Mr. Bruce Foote three were investigated, the Kandukur, the Ongole and the Vemavaram-Budavada. From the latter many specimens of plant remains and marine fossils were collected. The latter are not well preserved, but as their specific identification has not yet been attempted, it will be sufficient to enumerate the genera provisionally determined. These are *Leda*, *Lucina*, *Ostrœa*, *Exogyra*, *Pecten*, *Aucella*, *Arca*, *Tellina*, *Cyrena*, *Lima* (casts), a doubtful *Trigonia*, *Cardium*, *Pronoella*, *Alectryonia* and *Mytilus*, *Patella* (several species, large and small), *Natica* (casts), several species of *Rhynchonella* and *Terebratula*, and fragments of belemnites and ammonites.

Mention was made in the last General Report of certain black disc-shaped markings collected by Mr. Jones in 1921 from the Vindhyan rocks of Neemuch and sent to various authorities in the United States for opinion. The opinion of Dr. C. D. Walcott, Dr. E. O. Ulrich, Dr. R. S. Bassler and Dr. C. E. Resser of the United States National Museum is that they are true fossils and definitely brachiopods agreeing most closely with orms of *Acrothele* from the Cambrian. Professor B. F. Howell, of Princeton University, on the other hand, is more in favour of their being plant remains, since, when heated, the shiny film of the fossil—which is evidently the only part of the original organism now remaining—glows and burns to a grey ash. A piece of the shell of a Middle Cambrian phosphatic specimen of *Acrothele*, when tested in the same way, did not burn. Professor Howell remarks on the fact that there is no certain evidence of a beak or of any of the other features characteristic of *Acrothele* shells. He suggests that if the Vindhyan fossils are animal, they might be flattened phosphatic

shells of very primitive, probably pre-Cambrian, snails, and that they also resemble somewhat the opercula of certain Cambrian pteropods. Their identification, therefore, is still somewhat doubtful, although there seems to be a general consensus of opinion that the specimens are brachiopods of *Acrothele* affinities. The Suket Shales in which they occur are found beneath the Kaimur sandstone near Neemuch. The Kaimur sandstone is normally the base of the Upper Vindhyans, but, according to Dr. Heron, in the Neemuch area the Kaimur sandstone is succeeded in descending order by the Suket Shales, the Nimbahera Limestone, the Nimbahera Shales, and a very local basal conglomerate at Khori and Malan, with no break in the succession. Dr. Heron would regard the above beds as a local downward extension of the Upper Vindhyans below the Kaimur Sandstone. An alternative view is to regard the Kaimur Sandstone as the lowest division of the Upper Vindhyans and the Suket Shales as the top of the Lower Vindhyans, the Nimbahera Limestone, Nimbahera Shales and Khori-Malan Conglomerate all finding a place in the Lower Vindhyans.

During the year presentations of fossils were made to the following institutions:—to the Indian School of Mines, Dhanbad, a series embracing representatives of most of the invertebrate orders and extending from the Cambrian to the Pliocene ; to the Department of Zoology, Allahabad University, a similar series including a few vertebrate species ; to the British Museum (Natural History) duplicates of fossil mammals, chiefly from the Eocene of Burma, and casts of certain mammalian skulls and jaws which it is intended to figure in future publications.

MINERALOGY.

The chlorophæite series.

A doubt was raised during 1927 by Dr. Peacock of Glasgow whether von Waltershausen's term palagonite (1846) is applicable to the material to which this term has been applied in the Deccan Trap basalts and similar rocks in other parts of the world. Dr. Fermor, in his study of the basalts of Bhusawal, has already drawn attention to the similarity between chlorophæite (1825) and some palagonite, and a paper by him on the composition of chlorophæite is appearing in these Records. Using four analyses of chlorophæite from Nagpur, Edinburgh, Scuir Mohr (Island of Rum), and the Giant's Causeway respectively, Dr. Fermor finds that the following

general formula can be devised to interpret these analyses:—

$$2\frac{1}{2}H_2O.5R_2O_3.20SiO_2+n(RO.H_2O)+(80-4n)H_2O.$$

The water in the last term is that driven off below 100° to 110°C., whilst the water in the other two terms is that driven off above the temperature mentioned. Designating these as non-molecular and molecular water respectively, Dr. Fermor points out that the above formula shows that in chlorophæite there is this curious relationship between non-molecular and molecular water, namely that for each increase of 1 unit of molecular water there is a decrease of 4 units of non-molecular water. The specific gravity and refractive index increase with the value of n. The palagonite of Iceland is found to conform to this formula and hence it is deduced that the term palagonite has been correctly used in the terminology of Deccan Trap basalts. The term chlorophæite has priority and if the use of either term were to be discontinued, it should be palagonite. Dr. Fermor advocates, however, that chlorophæite should be used in a strictly mineralogical sense and that palagonite should be retained with a more comprehensive scope in accordance with which it implies not a definite mineral but rather a secondary hydrous rock of which chlorophæite may be one constituent. Palagonitisation is, then, the process by which this alteration is produced.

Specific gravity-ash relationship of Bokaro coals.

Some years ago whilst studying the coals of the Korea coalfield, Central Provinces, (Memoirs XLI, part 2, 1914), Dr. Fermor detected a definite relationship between ash contents and specific gravity. On taking up the geological survey of the Bokaro coalfield (1916-17) he found that a similar relationship applied to the coals of Bokaro. After eliminating certain discrepancies a definite empirical rule can now be formulated by the use of which it is claimed a prospector can determine in the field the approximate ash contents of specimens of coal. The rule is linear and is as follows:—

$$a=(g-k)\times 100,$$

where a=the ash contents of the coal, g=the specific gravity of the coal and k=the specific gravity of ash-free coal for the field. A paper on this suggestive and interesting subject is appearing in the Records of the Department (Vol. LX, p. 313).

Empire Mining and Metallurgical Congress.

The second Triennial Empire Mining and Metallurgical Congress

was held in Canada in August and September 1927. Mr. H. C. Jones, Assistant Superintendent of the Geological Survey of India, was deputed to represent his department at the Congress, but has not yet returned from leave, nor submitted a report.

Simla Hill States.

During the spring of 1927, according to plan, Dr. G. E. Pilgrim and Mr. W. D. West resumed work in the neighbourhood of Simla, the former mapping the country to the west of the Simla motor road, and the latter that between the Simla motor road and the Giri river.

The highly metamorphosed schists, quartzites, and carbonaceous limestone and phyllites of Simla and Jutogh, to which the name of Jutogh series has been given were found to form an isolated outcrop separated from the similarly isolated outcrops of Chail and the Chor. The boundaries of the outcrop have been followed north-west of Simla to Halog (Dhami State) and then south-east to about midway between the motor road and the Ashni river and thence back to Simla. Within these boundaries two carbonaceous bands have been recognized, though they have not everywhere been mapped. Both bands contain carbonaceous limestone at intervals, though in neither of them is it invariably present. These are considered to represent the same horizon repeated by recumbent folding.

The Jutogh series has been found to rest everywhere on the Chail series, though in Simla itself the latter thins out to some 30 feet, which were united by Oldham with the Jakko carbonaceous slates of the Jutogh series. The Chail outcrop, like that of the Jutoghs is isolated from the Chail beds of the Chor area ; it extends, however, much farther to the south-east and almost reaches the Giri river. The composition of the beds closely resembles that of the Chail series of the Chor area with one important exception : namely, that a lower horizon than any seen east of the Ashni river is exposed almost continuously from that river to Halog. These lowest beds are grey slates and banded limestones. The latter were correlated by Medlicott with the Blaini on the Sairi road and were mapped as such by McMahon (*Rec. Geol. Surv. Ind.*, Vol. X, pp. 204-223 (1877)) wherever they occur.

Dr. Pilgrim now has little doubt that the banded limestone

west of the Tons and 7 miles S.E. of Chakrata is identical with this Chail Limestone and does not belong to the Jutogh series, according to the view which he previously held and which was mentioned in the last Annual Report (p. 22).

To the north-east of the Giri the characteristic quartzites and conglomerates of the Jaunsar series crop out in two bands on either side of and dipping under the Chail outcrop. Mr. West has shown that the Jaunsars of the Simla and Chor areas are almost separate, but not quite as is the case with the Jutogh and Chail series, since a very narrow outcrop of them runs across the deep bed of the Giri, where for the most part only the underlying Blaini or Simla Slates are exposed. Mr. West had already shown that the Blaini dies out between the Giri and Ashni rivers so that the Jaunsars rest on the Simla Slates. Dr. Pilgrim has found that on the same line to the north-west it reappears, but is very inconstant and always thin. On the other hand the northern outcrop of the Blaini, which Mr. West has followed from the Giri to Simla, generally displays that series in an uninterrupted and typical development.

Both the bands of Jaunsar mentioned above thin out and finally disappear, when traced to the north-east, and the overlying Chail beds overlap them on to the Blaini or Simla Slates. Along the same boundary south of Halog, Dr. Pilgrim has also identified a thin band of the Subathu series, consisting both of the limestone—here almost unfossiliferous—as well as of the basal pisolitic laterite.

The three unconformities, referred to above fully confirm the conclusion previously arrived at, that each of them represents the trace of a thrust-plane.

Dr. Pilgrim appears to have demonstrated that the Chail and Jaunsar outcrops are each isosynclines of which the north-eastern limbs are missing either wholly or in part. South-west of Halog, the area between the Jaunsar thrust and another thrust which is assumed to be the continuation of the Giri fault, is also occupied by an isosyncline, of which the core consists of Simla Slates with Jaunsars on either limb. This in its turn is thrust over a folded series of Blaini and Infra-Krol which structurally seems to be in continuation of the Krol Hill.

Dr. Pilgrim's interpretation of the geology of the country between the Mahasu ridge and the Shali peak differs considerably from Captain Palmer's, a brief account of whose work was published

in the General Report for 1920 (*Rec. Geol. Surv. Ind.*, Vol. LIII, p. 10). He regards the Nummulitic beds as unconformable to the Madhan Slates and folded in with them; the latter series are probably Jaunsar. The extensive outcrop of slates and lenticular banded limestones which overlies the Madhan Slates was correlated with the lowest Chail horizon, the upper beds of the Chails being represented between Matiana and Narkanda by phyllites, talcose schists and quartz-schists; the whole sequence is disposed in a series of isoclinal folds within which occasional beds of a white quartzite, correlated with the Jaunsar, have been pinched in. Half-a-mile from Narkanda these beds are overthrust by highly metamorphosed mica-schists which are correlated with the Jutogh series. Of Captain Palmer's two alternative suggestions (1) that the limestone and slate series is Eocene, (2) that it is older than and thrust over the Madhan Slates, Dr. Pilgrim supports the second. He claims to have recognized the thrust-plane between Mashobra and the Nauti river, where the Chail limestone and slate series rests on some carbonaceous slates which pass up conformably into the Shali Limestone. He favours an age for the Shali Limestone immediately succeeding the Simla Slates, and regards it as probable that the Madhan Slates (?Jaunsar) are thrust over the Shali Limestone and do not overlie it in normal succession according to Palmer's view. At the same time the evidence at present available is not sufficient for a definite pronouncement on either point.

On the other hand the Naldara Limestone is considered to occur as lenticles near the base of the Simla Slate series, and to agree lithologically, with the so called Kakarhatti Limestone north of Subathu.

It is unnecessary to describe this work in greater detail here since a paper on the geology of the area has been submitted by the two authors and will be published shortly.

It has been decided to depute another officer, Mr. J. B. Auden to assist in this interesting Himalayan work. Mr. West will complete the survey of the area adjoining Simla and proceed south-eastwards in the direction of Chakrata with the aim of joining up with Mr. Griesbach's work in Kumaon, while Mr. Auden, after his initiation to the rocks of Simla, will work north-westwards with a view to joining up with Sir Henry Hayden's surveys in Lahaul and Spiti.

ECONOMIC ENQUIRIES.

Building Materials.

Keonjhar State: Bihar and Orissa.

Dr. Krishnan notes that the shales of the Iron Ore series in Keonjhar State, Bihar and Orissa are usually plastic and generally useful for making bricks and pottery. In the granite area also the weathering products of the felspar are seen to be good clay, but they are not found in bodies of any size.

Lower Chindwin district, Burma.

Mr. V. P. Sondhi reports that exposures of a compact, bedded sandstone of the Pegu series occur along the Ywashe-Yinmabin road, west of Monywa (Sheet No. 84 N/1). The stone is suitable for ordinary building purposes and can be easily trimmed and shaped. It is largely used by the Public Works Department in revetments and bridges.

Compact rhyolitic tuffs and agglomerate occur along the same road and are largely used as soling stone and road metal. They are found to withstand the local traffic in a satisfactory manner.

Limestone and Marble, Sirohi State; Rajputana.

Mr. Coulson describes a big spread of limestones and associated calcic rocks in the south-eastern area of Sirohi State, Rajputana. The purer varieties will only be utilizable when the present difficulty and cost of transport have been successfully dealt with.

Mr. Coulson noted a white marble at Ghoratankri (24° 22′ 30″: 72° 54′) on the border of Sirohi State with Danta State. This rock has been quarried in the past as a building-stone and takes a good polish. The amount, however, is limited and the rock is very variable in texture and quality; furthermore the deposit is some 12 miles from the nearest railway station (Abu Road) and means of communication are very poor. An analysis showed the rock to have 16·16 per cent. of insoluble residue and 70 per cent. of MgO.

Mr. Coulson noticed a white saccharoidal marble in the vicinity of Perwa and Serwa (24° 37′: 72° 36′) where it is quarried for use as a building-stone and to a lesser extent for lime. A sample from Perwa gave 8·52 per cent. of insoluble residue and 0·91 per cent. of MgO. The rock is not a good building-stone but occasionally blocks up to 8 feet long and 1½ feet across are quarried; most of the stone goes to Sirohi City, some 23 miles to the north-east.

Two outcrops of a white saccharoidal marble, separated by mica-schists, were found by Mr. Coulson at Piloti (24° 32′ : 72° 28′) in Sirohi State. This is burnt for lime; it is useless as a building-stone on account of the absence of well-defined joints, but takes a good polish. An analysis showed it to contain 3·47 per cent. of MgO and 3·96 per cent. of insoluble residue. What is probably the same rock is found at Maraichi (24° 31′ : 72° 30′), in three isolated outcrops to the south-west of Godwara (24° 33′ : 72° 27′ 30″) and to the north-west of Bhilra C (24° 32′ : 72° 27′ 30″).

Clay (See Building Materials).

Coal.

Lower Chindwin district, Burma.

Mr. B. B. Gupta reports that outcrops of coal were seen in the Yaw rocks in two localities, one of them half-a-mile north-north-west of Goonyibin Sakan (22° 15′ 30,″ 94° 36′) on the Goonyibin Petpetin-road, the other in the Kyochin Chaung, about two furlongs north-east of Kyochin. In Mr. Gupta's opinion these beds are of no economic value.

Attock district : Punjab.

Some worthless vertical seams of carbonaceous shale, with strings of coal, were found in gypsiferous shales interbedded in the Lower Nummulitic limestones near Surg village about 9 miles W. S. W. of Campbellpur in the Attock district of the Punjab. The greatest thickness of the carbonaceous shale and impure coal is 2¼ feet.

Copper.

Lower Chindwin district, Burma.

Mr. V. P. Sondhi records the occurrence of veins and impregnations of malachite and chalcanthite in the volcanic tuffs and agglomerate of Hill "937", west of Monywa. The deposit was opened up by Messrs. Jamal Brothers but the workings have been abandoned. The occurrence is about four miles north-west of, and similar to, that described in the General Report for 1926 (*Records, Geol. Surv, Ind.,* Vol. LX, pp. 27-28).

Engineering and Allied Questions.

Rangoon Hydro-Electric & Water Supply Survey, Toungoo and Salween districts, Burma.

Mr. P. Leicester was deputed to accompany the Rangoon Hydro-Electric Survey Party to report on the dam sites, reservoir areas, tunnel lines, etc. of the Lewa-Pyagawpu area of the Rangoon Water Supply and Hydro-Electric Scheme. The country traversed lies within the Survey of India one-inch-to-the-mile sheets, Nos. 94 B/16, 94 F/3 and 94 F/4, in the Toungoo and Salween districts.

The northern part of the area was examined and reported on favourably by Mr. E. L. G. Clegg in 1922, but the scheme has undergone some considerable revision since then and the Yunzalin Dam which gave the name 'Yunzalin Scheme' to the Project is not under consideration at the present.

Several alternative schemes were investigated by the Survey Party. The works involved may be included under the following heads :—

(1) Pyagawpu Reservoir Area with :—

Thelaw Klo main dam site.
Spillway into the Thelaw Klo.
Kailaw Klo stop-gap dam site.
Bilin stop-gap dam site.

(2) Upper Shwegyin Chaung Reservoir Area with :—

Alternative dam sites.
The low saddle spillway.

(3) Lower Shwegyin Chaung Reservoir Area with :—

Two alternative dam sites.

(4) Tunnel Lines :—

Upper Shwegyin Chaung Reservoir to Kwila with :—

Upper and Lower Syphon lines at Pokodo Auk.
Branch from (1) to the Power Plant site above the Lower Shwegyin Chaung Reservoir near the junction of the Malaw Klo with the Shwegyin Chaung.

Lower Shwegyin Chaung Reservoir (Malaw Klo) to north-east of Lewa.

Pyagawpu Reservoir to the Power Plant site in the Kailaw Klo Valley.

(5) Penstock Lines and Power Plant Sites :—

Alternative sites at Kwila.
North-west of Lewa.
In the Kailaw Klo Valley.

To summarise briefly the scheme as outlined by the Engineers, it is proposed to impound the waters of the Thelaw Klo and its tributaries by means of a main dam to the east of Pyagawpu and the Kailaw Klo and Bilin stop-gap dams. The water from this reservoir will be carried through a tunnel into the Kailaw Klo to join the waters of the Tiplu Law and the Kano Law and their tributaries, which will be impounded by means of the Upper Shwegyin Chaung Dam. Hence it is proposed to carry the water in a tunnel to the neighbourhood of Lewa and Kwila; after passing through a power plant and then through filter-beds, the water will be carried to Rangoon by a pipe line about 125 miles in length. It is also proposed to erect a power plant in the Kailaw Klo valley to receive the water passing through the tunnel from the Pyagawpu reservoir before it is finally discharged into the Kailaw Klo.

The Lower Shwegyin Chaung Dam comes under the heading of a separate scheme for the supply of electricity alone.

The rocks exposed within the area in order of their respective ages are :—

(4) Alluvium,
(3) Plateau Limestone,
(2) Granite, etc.—intruded into (1),
(1) Chaung Magyi series.

The older gneisses described by Mr. Clegg as occurring farther north are not met with in this area.

(1) The Chaung Magyi series, as identified by Mr. Clegg, is represented by quartzitic slates, shaly slates and quartzites. All grades from a dark blue, cleaved though broken slate to a hard, light coloured quartzite are seen.

In the northern part of the area a general strike N.-by-W. to S.-by-E. is maintained, and the dip varies in direction and amount. The series has been folded along axes running approximately N.-S. The Pyagawpu valley shows a westerly dip on the west and an easterly dip on the east and appears to be an eroded anticline. The contact-altered quartzitic rocks bordering the granite

in the south-western part of the area are jointed but have revealed no trace of their original strike and dip.

Near the granite contact the series is very highly metamorphosed. Near the junction of the Kano Law with the Shwegyin Chaung the slates are converted into schists and schistose slates, while, farther west towards Pokodo Auk, the metamorphism has been of a complex and severe nature.

In the Shwegyin Chaung below hill, " 3,076 " and about one mile south-east of Pokodo Auk, there are excellent exposures of gneissic quartzite and quartz schist. The gneissic quartzite has irregular crystals of quartz scattered in a groundmass of smaller quartz crystals and a little accessory felspar. Nests of pale brown biotite, chlorite and a little magnetite occur. The quartz schist has elongated quartz crystals showing strain, ranged in bands with interstitial chlorite and a little magnetite.

Passing northwards the rocks vary considerably but are what would be expected within the metamorphic aureole where a series of sandstones and quartzites, with interbedded shale, has been intruded by granite. They comprise: siliceous hornfels, felspathic hornfels (leptynite), felspathic granulite, felsite, highly metamorphosed quartzite with pyrites and highly altered shale or slate. The whole is intruded by veins of quartz, aplite and some basic rock which has been converted into amphibolite.

From north-east of Lewa to the junction of the Kano Law with the Shwegyin Chaung granite is traversed and the Chaung Magyi series, into which the granite has been intruded, lies to the north. About a mile to the south-east of Pokodo Auk the Chaung Magyis descend into and cross the Shwegyin Chaung, south of hill " 3,076"; passing northwards across the slate series to Pyagawpu the granite reappears to the east and north-east of the Pyagawpu valley and the rounded radiating spurs of the granite hills contrast with the parallel ridges of the Chaung Magyis.

The granite occurs as fine and medium grained boitite-granite which may possibly represent two stages of intrusion. Associated with the granite are veins of quartz and aplite and dykes of dolerite and hornblende-granophyre with pyrites and hæmatite.

The Plateau Limestone, which is believed to be of Permo-Carboniferous age, occurs as small outliers resting upon the Chaung Magyi series. The rock varies from grey to blue and white crystalline limestone, veined with calcite, and occurs as jagged peaks with pre-

cipitous tufa-covered slopes. The occurrences mapped by Mr. Leicester are :—

(*a*) Either side of the Kailaw Klo, three miles due south of Pyagawpu.

(*b*) A small outlier in the Kailaw Klo valley south of (*a*)

(*c*) On the left bank of the Tiplu Law near its junction with the Shwegyin Chaung.

(*d*) In the bed of the Thelaw Klo at Pyagawpu.

There appear to have been two phases in the deposition of the Alluvium in the area traversed. The earlier alluvium is found to compose the low flat ridges in the valleys, and consists of gravel and sand capped by a thick layer of soil. The more recent alluvium is capped either by light brown earthy alluvial clay or sandy soil with layers of sand and gravel of a very much fresher and purer nature than that found on the higher ground.

The proposed tunnel lines including the various alternative routes may best be referred to under the following heads :—

(1) Upper Shwegyin Chaung Reservoir to Kwila with :—

$\left.\begin{array}{l}\text{(a) Upper}\\ \text{(b) Lower}\end{array}\right\}$ Syphon Lines at Pikodo Auk.

(2) Branch from (1) to the Power Plant Site above the Lower Shwegyin Chaung Reservoir near the junction of the Malaw Klo with the Shwegyin Chaung.

(3) Lower Shwegyin Chaung Reservoir to north-west of Lewa.

(4) Pyagawpu Reservoir to Power Plant Site in the Kailaw Klo Valley.

The tunnel lines were geologically examined with a view to ascertaining (*a*) the stability and immunity from falls and (*b*) the immunity from loss of water through leakage of the proposed tunnels.

(*a*) The tunnels, Nos. 1, 2 and 3, pass through granite except for about one mile of metamorphosed quartzitic rocks, belonging to the Chaung Magyi series. which are crossed by tunnels Nos. 1 and 2 near Pokodo Auk (97° 1′ 15″; 18° 14′ 32″). The granite is stable and the joints generally cross the tunnel lines obliquely.

The jointing in both ·· granite and the quartzite at the Upper Syphon Line is extensive, and Mr. Leicester considers that the tunnel should be lined as a protection against falls and leakage for at least 100 feet on either side of each crossing. Two streams are crossed and this necessitates a total length of lining of 400 feet.

The tunnels should also be lined where they pass into the decomposed rock overhead, which they are likely to do if they pass less than 50 feet below the surface.

If the tunnel, No. 2, to the Lower Shwegyin Dam Power Plant (Malaw Klo) pass through the narrow point on the ridge (97° 0′ 50″; 18° 13′ 20″) the hillsides should be drained to prevent slips and further erosion by the temporary streams that are formed during the height of the rainy season.

(*b*) In the solid granite there should be practically no loss of water through leakage as most of the joints visible at the surface will be closed at the depth of the tunnel. Any open joints met with, however, together with the margins of quartz veins and faults, must be well grouted.

As already mentioned the tunnel at the Upper Syphon Line near Pokodo Auk should be lined on account of the number and character of the joints in both the granite and the quartzitic rocks which might give rise to falls. These joints which are open cracks in the rock, would, in Mr. Leicester's opinion, allow a great quantity of water to escape if the tunnel were not lined.

The assemblage of contact rocks grouped under the heading of quartzites and gneiss are hard; some, such as the siliceous hornfels, will not be easy to excavate. They are stable and impermeable, but a number of open joints may be expected and these should be well grouted to prevent loss of water through leakage.

The decomposed granite of the district probably extends to an average depth of 30 feet below the surface. It is porous and, where the tunnel passes into it, will require lining. This is particularly necessary where the tunnels enter and leave the ground. A loss of head on account of the friction caused by the rough surface of the granite is anticipated.

Tunnel No. 4, from Pyagawpu Reservoir to the Power Plant Site in the Kailaw Klo valley, is 6,100 feet in length, has a direction N. 26° E.—S. 26° W., and passes through a ridge of shaly slate which has a general direction N. 20° W.—S. 20° E. The strike of the shaly slate is N. 15° W.—S. 15° E. The dip was nowhere visible, but it is presumed to be westerly in agreement with the dip of the slates in the same ridge further to the north.

The ideal section would be one in which the direction of the tunnel line were at right angles to the strike of the rock. In the present case the tunnel line crosses the strike obliquely at an angle

of 41° which should be sufficiently large for the stability of the tunnel.

Mr. Leicester remarks that there should be no necessity of lining for the prevention of falls in the hard slate, but where the rock is decomposed or soft, at the entrance and exit, the tunnel will need lining. The tunnel should have a circular outline and the walls should be made as smooth as possible to prevent the water under pressure from pressing into the cleavage planes of the slate and tearing off small angular fragments. It is presumed that the water passing through the tunnel will not carry large quantities of silt coarser than 0·2 mm. in diameter.

The tunnel should be satisfactory and safe from falls under a head of 50 feet as required. The rock is impermeable and there should be no fear of loss of water through leakage.

The rock at the Upper Shwegyin Chaung dam site is a medium grained biotite-granite traversed by dykes of hornblende granophyre and occasional quartz veins. The general direction of the joints is parallel to the direction of the dam line. About half-a-mile to the north and north-west slates overlie the granite; these are the slate facies of the series of quartzites and slates mentioned by Mr. Clegg in his report as probably belonging to the Chaung Magyi series.

Most of the granite at the dam-site is decomposed to considerable depths, and trial pits along the main dam line on the right bank reveal solid granite between 18 and 33 feet. On the left bank, which is particularly unpromising, no solid rock has been reached. The slope, unlike that on the right bank, is backed by a very steep ridge rising to a height of 4,000 feet above sea level. The lower slopes are partly composed of scree, and the granite has been greatly decomposed by the water collected on the ridge behind. It seems that all this water does not reach the main *chaung* by streams but soaks into the hillside which forms the left bank of the Shwegyin Chaung at the dam site. The decomposed granite is porous and, owing to its sandy nature, is liable to be washed down by running water except where is thickly covered with vegetation.

The uniform nature and extent of the decomposed granite renders it comparatively immune from slips, the only danger being that of the washing away of the loose material near the surface. The decomposed rock on the right bank is more compact and therefore more stable. The ground above the dam on either side should

be drained as far as possible in order to minimise further decomposition and prevent water from soaking into the dam from the side.

From a geological point of view Mr. Leceister considers the line to be unfavourable. The construction of a dam upon debris and semi-porous granite is objectionable, and to reach solid rock the foundations on thel eft bank would have to be sunk to a considerable depth.

The alternative line, across from the small stream-course on the right bank above the main dam lines to the stream-course on the left bank, reveals bare rock throughout nearly the whole length. The granite in the small stream-course on the right bank is a little crushed and one or two porous fractures are visible. If, however, the foundations of the centre wall of the dam are sunk well into the rock there should be no trouble from leakage. This line has the disadvantage of necessitating a long and irregular dam. In the case of a line from the stream-course on the right bank straight across to the rising ground on the left bank, although there is considerable saving in length of the dam, the rock on the left bank at this point is little better than that on the same side at the main dam line.

On the right bank the depth at which sound rock will be found is known. It is revealed by the pits on the main dam line. It seems that the best line would be one from the stream-course on the left bank across to the hillsides on the right bank.

The bed of the Upper Shwegyin Chaung Reservoir, from the dam line up to Longitude 97° 6′ 30″ and up to the Kano Law ⅜th mile from its junction with the Shwegyin Chaung, is composed of granite. Slate occurs from Longitude 97° 6′ 30″ up the Shwegyin Chaung to the junction with the Tiplu Law. The rock up the Kano Law is slate, and slate forms the bed of the Kailaw Klo within the Reservoir area except for some limestone just north of the meeting of the Tiplu Law with the Shwegyin Chaung. This limestone is younger than the slate and overlies it. It should not be the cause of any leakage.

Mr. Leicester reports that both the granite and the slate are impermeable and are highly suitable for the floor of a reservoir.

The Tiplu Law flows on granite and through alluvium resting on the granite, but near the village of Kawleido (between Lats. 18° 15′ 5″ and 18° 15′ 20″) on the right bank of the stream, is a hill of limestone; this is apparently outside the reservoir area since the 2,000-foot contour is much lower down stream than is

shown on the one-inch map. Field evidence is slight but even if the water were to come up as far as this point it is unlikely that any considerable quantity would be carried out of the catchment area.

The banks of the reservoir are stable except at the end of the ridge on the right bank of the Shwegyin Chaung about one furlong north of the main dam line overlooking the stretch of alluvium through which the *chaung* meanders. Here slips had occurred and further slips may be expected, but these, it is thought, will be small and will not have any serious effect on the reservoir. The decomposed granite which forms the banks of the reservoir as far as the Kano Law is liable to be washed into the reservoir causing a certain amount of silting up if the vegetation here be not encouraged to grow down to the water level.

The trial pit on the low saddle passes through sandy and argillaceous decomposed granite and reaches a depth of 25½ feet without striking solid rock. The argillaceous decomposed granite is impermeable or nearly so, but the sandy decomposed granite is porous. If an impermeable wall were made with its foundation in the clayey decomposed granite, there should be no loss of water through leakage, but the comparatively soft rock will give slightly under any great weight It is difficult to say at what depth solid rock would be found if required. It should not be expected at a lesser depth than 50 feet.

For the Lower Shwegyin Chaung dam there are two alternative sites both of which are situated on fine-grained biotite-granite. On the upper line sound rock is exposed on the left bank but the right bank is composed of alluvium and talus with large boulders of granite resting on the granite. The dam foundations will of course have to be carried down through the superficial deposits which appear to be about 30 feet in thickness.

On the lower alternative dam line good medium to fine-grained biotite-granite is exposed on the right bank and on the left bank is the steep slope of a granite hill on which outcrops of granite are visible, there being but little decomposition of the rock. A large bed of boulders occurs in mid-stream.

The Lower Shwegyin Chaung Reservoir Area lies entirely on granite which is covered in places by talus with large boulders and alluvium. The granite is not highly jointed and although the joints cross the direction of the dam line obliquely, since they

are not open cracks, no water is likely to be carried from the reservoir.

The new Thelaw Klo dam line is farther down stream than the line examined by Mr. E. L. G. Clegg in 1922, being about ¾ mile N. E. of the V-shaped bend in the Thelaw Klo, S.E. of Pyagawpu (97° 7′ 4″; 18° 20′ 5″). Outcrops of solid slate occur on either bank of the stream, the slopes of the valley are steep and stable and the hillsides are covered with trees and undergrowth. Trial pits on either slope have reached solid or nearly solid slate at reasonable depths. Though solid unaltered slate has not been reached in every case the rock met with is firm and impermeable and capable of bearing considerable weight. The weathered slate makes a good impermeable clay. This, Mr. Leicester reports, is an ideal site for an earthern dam and should be satisfactory for a masonry dam provided with suitable foundations.

The site for a spillway into the Thelaw Klo is in a col situated 1,700 feet S. E., of the Thelaw Klo dam site. The trial pits which have been sunk along the line show soil and residual clay overlying decomposed slate on either side, and the centre pit which has been sunk to a depth of over 40 feet passes through brown residual clay. The rock is impermeable and the slopes of the valley are stable. The site is geologically satisfactory.

The site selected for the Kailaw Klo stop-gap dam is situated not so close to the divide as that previously inspected by Mr. Clegg. The rock here is slate with a strike N. 22° W.—S. 22° E., and a vertical dip. Tle trial pits like those at the spillway reveal clay and decomposed slate. The sides of the valley are stable and the clay and decomposed slate are impermeable. The site is satisfactory.

The new site selected for the Bilin stop-gap dam is farther to the south than that previously examined by Mr. Clegg. It is situated about ¼ mile N. W. of the point where the Bilin Chaung reverses its direction from a northerly to a souther'y route, about 2¾ miles S.E. by S., of Pyagawpu village. Trial pits show a capping of soil followed by alluvial clay with interbedded gravel resting upon the residual clay of the slate series beneath. To the south there is a sudden drop of 75 feet to the Bilin Chaung beneath, exposing a cliff face of slate capped by alluvial clay with interbedded gravel. It is here that the Bilin Chaung changes its direction from N.W. to S.E. by S. It appears that the upper

waters of the Bilin Chaung did not originally belong to that stream but flowed northwards into the Thelaw Klo along the now practically dry alluvium-covered valley in which the proposed dam site is situated. The Bilin Chaung must, in cutting its way back, have captured the upper waters of the former stream. It has since gone on cutting its way downwards through the alluvium and the underlying slates until at the bend it is now 75 feet below the valley of the former stream.

The trial pits appear to have passed through the alluvium and reached residual clay and, as the dam site is as much as 1,000 feet from the cliff face, there should be no fear of leakage of water through layers of gravel. The country rock is shaly-slate, the hillsides are stable and the clay met with impermeable, so that the site is satisfactory geologically.

The Pyagawpu reservoir area is contained in a long and broad valley, the northern portion of which runs N.—S. and the southern portion N.N.W.—S.S.E. The Thelaw Klo meanders through this valley in a general westerly direction and is met by the Pele Law from the north and by a seasonal stream from the Bilin gap in the south.

The floor of the valley is covered by thick and fertile alluvium and the hills on either side consist of slate with a general N.-by-W. strike. The dip is steep and sometimes vertical; in general it is inclined steeply to the west on the western side of the valley and to the east on the eastern, thus indicating that the Pyagawpu valley is probably a denuded anticline, with its axis running N.-by-W. to S.-by-E.

In the centre of the valley blue and white limestone crops out in the bed of the Thelaw Klo. This limestone, like that in the Kailaw Klo valley and the limestone described by Mr. Clegg in his report on this area in 1922, would appear to be an outlier of the Plateau Limestone which originally covered the area. The limestone is situated completely within the reservoir area and, being younger than and lying on the top of the slates of the Chaung Magyi series, it cannot be the cause of any leakage.

Mr. Leicester finds that both the floor and the walls of the impounding area are impermeable. The alluvium is mainly argillaceous and only slightly arenaceous and the foundations of the dams will in any event be carried down to the impermeable slate series so that no leakage need be anticipated.

The slate series also forms the walls of the impounding area. The dip is outward but, as the series is quite impermeable and there is no trace of faulting, the rocks should prove quite water-tight.

The hill-sides are stable and not liable to falls with the exception of small unimportant earth slips which may occur on the west side of the valley just north of the site for the intake of the tunnel to the Kailaw Klo power plant. The reservoir area is reported as geologically satisfactory.

The Power Plant sites and Penstock lines examined were in every case satisfactory geologically. The Penstock lines, excepting the line in the Kailaw Klo valley, descend steep granite spurs covered by large granite boulders which appear to be firm and are not likely to fall except in the event of an earthquake of exceptional severity.

The line to the Power Plant Site in the Kailaw Klo valley descends a hill-side of slate which is stable and not prone to slips. The power plant site is situated on firm limestone near the left bank of the Kailaw Klo.

The Lewa-Pyagawpu area displays the most striking changes brought about by chemical decay or decomposition. Humic acids appear to be responsible for very considerable rotting of the rock. Mr. Leicester notes that, from a study of the trial pits sunk on the Upper Shwegyin Chaung and Thelaw Klo dam-sites, one cannot but notice the great depth to which the rock is decomposed on the thickly wooded hill-sides, and the comparatively fresh condition of the rock in and near the banks of the streams where the ground is well drained and the rock washed by the comparatively fresh water of the streams.

It has been observed that though the trial pits sunk in the course of the work carried out by the Consulting Engineers in the Lewa-Pyagawpu areas originally reached solid rock, in many cases the rock at the bottom of the pits was found to have become soft after a short time. This is undoubtedly the result of the action of humic acid carried by percolating water. It appears, therefore, that in order to preserve the rock from decomposition it is necessary either to remove the vegetation which is the source of the acids or to design a system of drains which will prevent the acid surface water from coming into contact with works such as the shoulders of dams and the entrances and exits of tunnels. In the hot and very damp jungle of the reservoir area dense undergrowth springs up in a very

short time so that to keep the hill-slopes perpetually cleared would involve considerable labour and heavy maintenance charges. Mr. Leicester agrees with Mr. E. J. Bradshaw that in practice it will be found best to effect a compromise between the two methods

Owing to the decomposed state of the surface rock the dams will necessarily have to be carried well into the hill-sides until solid impermeable rock is reached. The hill-sides above the engineering works should be very thoroughly drained in order, as far as possible, to divert the surface water from the works.

Besides the drainage system the ground in the immediate vicinity of the shoulders of dams and similar works should be kept stripped of all vegetation; in addition the ground at the entrances and exits of tunnels should be protected with concrete.

Before the reservoir is filled the basin should be cleared of weeds to prevent pollution of the water by a mass of decaying vegetation.

Landslip in the Waller Gorge, Bawdwin Mines, Namtu, Burma.

On the 6th August, 1926, a disastrous land-slide occurred in the Waller Gorge, near Tiger Camp of the Bawdwin Mines, Upper Burma, carrying away several houses and causing fatal injuries to forty-five persons. In response to a request from the Chief Inspector of Mines to the Geological Survey of India for advice as to the cause of the slip and the avoidance of similar accidents in the future, Dr. J. Coggin Brown was deputed to examine the ground in the month of March, 1927.

Waller Gorge contains the coolie quarter of Tiger Camp and is a narrow V-shaped valley formed by a small tributary of the Nam Pang Yun, the affected portion being close to its junction with the parent stream, and lying entirely within a group of rocks to which Dr. Coggin Brown gave the name "Pang Yun Beds" in 1914. These strata are in absolute conformity with the fossiliferous Lower Naungkangyis of Ordovician age above them, and pass without a stratigraphical break of any consequence into the Bawdwin tuffs and rhyolites below. They are quite unfossiliferous and their age is either Lower Ordovician or Cambrian. Quartzites, shales and slates of various kinds are the prevailing rock types with the former predominating in the vicinity of Tiger Camp. Owing to the proximity of the great overthrust fault of Bawdwin the quartzites are often broken up into small cleavage fragments, and there is other evidence of the severe shearing stresses to which the rocks have been subjected.

As a consequence of the steep easterly dip the eastern side of Waller Gorge forms a high scarp in which the broken edges of the Pang Yun quartzites are visible. On the western side of the gorge the smooth stratification planes of the quartzite can be seen dipping at high angles into the valley below. Where the dip is not too steep, the rock is covered by a variable thickness of light sandy soil, full of small fragments of quartzite. When the steep dip is taken into consideration, it is remarkable that these accumulations of debris can remain for long in the position they occupy, for there is little cohesion in the material itself. The surface covering the grass and vegetation doubtless acts as a protective agency in this respect.

The rainfall throughout Burma in August, 1926, was phenomenal and unprecedented. On the 14th, 15th and 16th a record total of eight-and-a-half inches fell at Bawdwin Mine. After a careful examination of the site Dr. Coggin Brown came to the decision that water was the chief cause of the disaster, which he describes as a true soil-cap slip commencing possibly as a creep—the usual sequence of events in movements of this kind. He points out the necessity of distinguishing carefully between such soil-cap slips and true rock slides. In the case under consideration there was no movement of the underlying rock.

Weathered rock debris such as has been described above absorbs rain-water easily; the greater part of the water remains in the decomposed layer and, flowing along between its lower surface and the underlying quartzite, finally issues as springs at the bottom. The presence of large quantities of water in such material makes it more mobile, the springs commence to erode the "toe," and the coefficient of friction is reduced until the mass is in a state of unstable equilibrium. A heavier burst of rain completes the cycle; gravity asserts itself and the whole sodden mass slips down the slope, gathering velocity as it does so, until, like a flood from a breached dam, it sweeps all before its path. In the case under consideration about 150 feet of railway line, with sleepers complete, were carried away and seem to have exerted a plough-like action which accentuated the general destruction.

As a general rule the dips are inwards, towards the valley, and vary from about 45° to 75°; in exceptional cases the rocks are vertical, and there is some variation due to rolling and to the proximity of the overthrust. The dip is thus higher than the angle of slope

of the sides of the ravine. Particularly noticeable are the big expanses of smooth, almost polished surfaces of the stratification planes of the quartzites where the covering has been removed. Dr. Coggin Brown could find no evidence of any particular zone of shattering. He noticed that north of the slip the sides of the ravine are less steep and appear to have flattened to the angle of repose. The present slip appeared to him to be but a small incident in the host of similar events which took place on the hills around, many of them on a much larger scale.

Hill-sides formed by steep dip slopes and covered with porous soil caps cannot be regarded as stable in rainy weather in this region. At the best of times they are insecure; during torrential rains they become dangerous, particularly if a stream is eroding the foot of the slope. The hills around are undergoing active denudation and are changing their shapes and contours as quickly as natural agencies can accelerate the process. Phenomenal variations in the sub-ærial conditions to which such unstable systems are exposed must result in unusual consequences. The Waller Gorge slip was one of these.

In Dr. Coggin Brown's opinion drainage as a treatment for the case is rendered impossible by the local conditions at Waller Gorge and he suggests that dwellings which are in perilous situations should be moved to safer locations. He considers it unlikely that the present slip will extend, though a certain amount of loose material will be washed down during succeeding rainy seasons. To the north the ground is safer by reason of its lower inclination, while to the south a solid rock "toe" is exposed for some little distance down the line. As a precautionary measure Dr. Coggin Brown recommends the removal of the two barracks which at present occupy sites near the southern lower edge of the slip.

Papanasam Hydro-Electric Project, Tinnevelly district; Madras.

A scheme for the generation of electrical energy at the edge of the Cardamom Hills, in the Tinnevelly district, is under consideration by the Madras Government and Mr. W. D. West was deputed to examine the geological aspects of the scheme. Power is required chiefly for the establishment of paper mills near Papanasam. For this purpose it is proposed to conserve the waters of the Tambraparni river where it emerges from the hills by two reservoirs. The main reservoir will require a long and rather costly dam. It is more economical, therefore, to divide up the area into two parts

and to conserve the waters of the higher streams by a second reservoir further up the valley, for which a shorter and cheaper dam will suffice. This will enable the main dam to be kept as low as possible, and will at the same time utilise the whole of the catchment area.

The lower of these reservoirs will occupy the ground above and below Mundanthurai (77° 21′ : 8° 41′), the suggested dam site being the narrow ridge of rock that cuts the main road about halfway between the second and third milestones. The dam site of the upper reservoir is situated a little south of the eighth milestone, where the river passes through a narrow gorge shortly after its junction with the Kari Ar.

As regards the lower dam site, its full height at the deepest point will be about 117 feet, and the length of the main deep portion about 3,000 feet. The rocks of this district are coarse-grained, gneissose biotite granites, rich in pink garnets. They strike W. 30° N.—E. 30° S., *i.e.* approximately parallel to the length of the dam. Mr. West reports that the rock is sound, but well jointed. The joints, though open at the surface, will probably be found to be fairly tight in depth, though trouble may be encountered locally. One or two pits have been dug along the site, and examination of them shows that the site is quite practicable. There is also a suitable saddle for the discharge of surplus water. The question of cost, however, is an important one in a scheme of this kind. As the rock is the same throughout the site, it is suggested that two deep trenches be dug right across it, rather than a number of small ones along the whole length. It is thought that the information obtained from these should be sufficient to enable the cost of the whole scheme to be estimated fairly closely. The local stone should be suitable for construction.

The dam for the upper reservoir will have to be about 185 feet high and about 850 feet long. This site also is parallel to the strike, and is located at a point where the valley narrows considerably, the constriction being due to a bed of charnockite which has been intruded along the strike of the country rock. The latter is mainly an acid gneiss and has a rather pronounced bedding which dips down-stream at about 25°, so that the charnockite outcrop is V-shaped, pointing down-stream a little obliquely. It thus comes about that the left flank will be entirely in charnockite, while the right flank will be partly in charnockite (the lower two-thirds) and

partly on the acid gneiss. It is not anticipated that the junction of the two rocks will be a source of danger, and the site as a whole was considered by Mr. West to be very satisfactory.

Pinjikave Hydro-Electric Project. Palni Hills, Madura district : Madras.

The Pinjikave Hydro-Electric Project is located in the Palni hills, 10 to 20 miles west of the hill-station of Kodaikanal. The power obtained is likely to be used for the electrification of the railway in the Madura district. The project includes a number of schemes, all of which, however, are not absolutely necessary for its success. The examination of the geological side of these schemes also was entrusted to Mr. W. D. West.

About 10 miles west of Kodaikanal a small reservoir is already in existence. This is situated on a low watershed, separating the streams with a N.W. trend from those flowing to the S. and S.E. The main idea is to impound the waters of the north-westerly-flowing streams by four dams, and to convey the water by a flume channel and a tunnel to the northern edge of the hills, where a fall of about 2 750 feet can be obtained. The four reservoirs are named: the Upper Koniar, the Lower Koniar, the Kodiyetanar and the Pulavachiar.

There is an alternative scheme by which the waters collected by the Upper Koniar dam can be conveyed into the existing reservoir, and thence by a channel for about a mile to the south-east of Berijam, where a fall of about 5,000 feet can be utilised.

The rocks throughout the district are nearly everywhere charnockite. The Lower Koniar dam site is the only exception. This rock has peculiar weathering properties, which have become emphasised by the very long period to which these hills have been subjected to denudation. When fresh it is a perfectly sound granite-like rock, usually well jointed. It is, however, sometimes found weathered very deeply, the weathering proceeding along the joints, so that cubical masses of fresh rock are left surrounded by completely decomposed rock. Mr. West remarks that it is thus not easy to predict from an examination of the surface of the ground the nature of the rock beneath.

The Upper Koniar dam site is situated at the end of a remarkably good reservoir site. Above the dam site the Koniar meanders through a wide, flat, alluvial valley, which is ideal for the formation of a reservoir. The construction of a dam here is, therefore, much to be desired. The dam will have to be about 70 feet high.

The rocks here, while apparently all charnockite, show a rather conspicuous bedding, striking along the stream and with a steep dip into the left flank. While the left flank of this site seems quite satisfactory, on the right flank the rock is deeply weathered and not at all suitable. There is a possibility of a better site further down-stream, but nothing definite can be said until excavations have been made.

The waters of this reservoir can either be used to supplement the waters of the other three reservoirs, or they can be used separately and conveyed into the existing reservoir at Berijam, and thence to the south-east to the head of the pipe-line. For the latter purpose it would be necessary to convey the water from the south-east end of the Berijam reservoir either by an open flume channel or by pipes. Information was required as to the possibilities of either method, for the course to be followed has been the scene of several landslips. Examination of the ground shows that landslips have occurred in the material formed by the disintegration of a banded gneiss. This process has proceeded very completely, forming a soft, bright red, powdery substance containing patches of kaolin. It is this material which has slipped, not the fresh rock. Mr. West, however, finds it impossible, to predict the depth at which solid rock may be found at any particular point. In the circumstances the alternative possibility of putting down a pipe-line would seem to be the only course, should it be desired to proceed with the scheme. This would of course be equally subject to the ill-effects of the slipping, but would have the advantage that it could be repaired more rapidly than an open flume channel, provided spare pipes were kept on the spot.

The Lower Koniar dam site is situated just below where the Kavinge-Kodaikanal road crosses the Talaivarai Ar. The dam is to be about 150 feet high and 800 feet long. This is the only dam site in this project that is not located entirely on charnockite. The rocks vary considerably, but they consist in the main of biotite-gneiss and charnockite, the latter varying from a very coarse siliceous variety to a fine-grained basic type. The strike of the rocks is parallel to the stream. The pits that have been dug indicate that, while the construction of a dam at this site is by no means impracticable, it is clear that it cannot be done cheaply. On neither flank does there seem to be any chance of finding solid rock up to the level of the top of the dam, however far one exca-

vated into the hill-sides. It is possible that the difficulties could be overcome by building only the central part of the dam to the full width, and extending the narrower flanks of the dam into the hill as a concrete core, founded on solid rock, but not necessarily ending against it. The suitability of this site for a dam really resolves itself into the question as to whether the enhanced cost of a dam on such a site is worth while.

The Kodiyetanar dam site crosses the Kodiyetan Ar close to the road to Kodaikanal. The site consists ot two rather rounded hills, covered mainly with grass, but with rounded outcrops of rock scattered about here and there. A very complete series of pits supplies all the information required. The height of the dam is to be 150 feet. This area was once all massive charnockite.

It is now almost completely disintegrated; and the misleading outcrops of rock seen scattered over the surface of the hills are really relics of the once fresh rock left in a mass of soft earthy material, the disintegration being nearly complete. Mr. West reports that it is quite clear that any kind of large masonry dam is quite impracticable at such a site, and the scheme must evidently be abandoned, for there seems to be no better site.

The Pulavachiar dam site is situated a little way above where the Vandaravu path crosses the Pulavachi Ar. The stream here follows a fairly straight course through a narrow valley, the high and fairly steep sides of which appear to provide an excellent site for a dam, which is to be about 180 feet high. The rock is charnockite, and owing to the steepness of the ground seems to be quite fresh and sound. The site is a good one for a gravity dam, while there are also possibilities for an arched dam, the cost of which would be much less.

After the waters of these four reservoirs have been collected together, they have to be conveyed about three miles to the pipe line, and this involves the construction of a pressure tunnel, over a mile long, about three miles north-west of Kavinje. The rock forming the greater part, if not the whole, of the tunnel line is very probably charnockite. It is fairly well jointed, but appears to be sound, forming great vertical precipices. It has not the appearance of being deeply weathered, the topography suggesting masses of fairly fresh rock. Except for the jointing, which may give trouble in the way of leakage, the rock is thought by Mr. West to be probably quite suitable for the construction of such a tunnel.

It will be better, however, if the course of the tunnel be slightly modified, so as to allow both a greater cover and a greater horizontal distance of rock to intervene between the tunnel and the surface, to withstand the pressure at two rather weak points.

Dam-site, Tungabhadra river, Bellary district; Madras.

In response to a request from the Government of Madras who are considering the revival in a modified form of the old Tungabhadra Irrigation project, Mr. Vinayak Rao was deputed to report upon the geological aspects of the scheme.

The country near Timmalapuram on the Madras side of the Tungabhadra River has only one ridge which comes within half-a-mile of the river. The rest of the country slopes upwards to the hills some miles away. On the Bombay side of the river low hills extend along the northern bank and the hill mass of Shingtalur lies right on the bank of the river.

The rocks consist of Dharwar quartzites, schists and banded quartzites with conglomerates and diabase dykes. Though there appears to be a repetition of the beds, it is not likely to affect the foundation as the beds are dipping at high angles. On either side of the Dharwars are granites and gneisses. The dam would cut across the Dharwars almost at right angles to the foliation planes. According to Mr. Rao this is the only possible site for a dam for miles since, either up or down the stream, the dam would have to be undesirably long. Most of the beds here are impervious to water. The site appears to be a suitable one, but trenches would show the nature of the foundation and a further examination of these when constructed will enable conclusions to be more definite.

Dam-site, Kolab river, Jeypore Estate, Vizagapatam; Madras.

During the season Rao Bahadur M. Vinayak Rao was deputed to inspect the site selected for a dam on the Kolab river in the Jeypore Estate of Madras. The rocks at the proposed site consist of charnockites of the acid variety. They have generally a north and south foliation and are considered to be well suited for a dam site.

Landslips, Naini Tal; United Provinces.

In response to a request from the Government of the United Provinces Mr. A. L. Coulson was deputed to make a re-examination of the condition of the hills in and around Naini Tal in September and October. A

committee was convened to examine the whole question and to consider more especially the following points:—

(*a*) the maintenance of existing protective works;
(*b*) the need for further protective works;
(*c*) existing observation stations and the need for additional stations;
(*d*) lake regulation and the authority for its control;
(*e*) authority for excavation, building and tree-cutting;
(*f*) the assessment of rain-fall run-off, normal leakage and evaporation;
(*g*) the verification of the catchment area and the question as to whether or not the Sukha Tal area should be included;
(*h*) the method of calculation of discharges and the assessment of a reasonable figure for the run-off;
(*i*) the method of recording rain-gauge readings:
(*j*) the removal of the large rock above the East Laggan road and near Killarney House;
(*k*) periodical inspection of the drains; and
(*l*) the examination of Charta Hill and Amparao.

The findings of this committee will be published in due course. Compared with other Himalayan hill-stations, Naini Tal has always suffered unusually from land-slip. The root of the trouble is a fundamental one, namely, the lesser degree of metamorphism undergone by the rocks composing the hill-slopes. The suggestion of the 1907 committee that the condition of the hill sides should be reported upon at intervals of not more than three years, is one worthy of support. With some of the other members in sub-committees Mr. Coulson considered in detail items *a*, *b*, *f*, *g*, *h*, *j* and *l*; in addition he submitted notes relative to China Hill, the Ballia Ravine, Kalakhan Hill, Durgapur Power House and the Depôt Road subsidence.

The chief reason for the constitution of the present committee lay in the fact that the Public Works authorities at Naini Tal were unable to account for about 70 per cent. of the water falling in the catchment area of the lake, the figure for the percentage run-off for 1925 being 30·4 per cent., the lowest on record. As this figure is regarded as the index figure for the safety of the settlement, alarm was felt at its extreme lowness, more especially so as the percentage run-off for 1918 was 82 per cent., there being a more or less constant diminution since that year.

In conjunction with Mr. Tunnicliffe, Mr. Coulson was able to account for 73·5 per cent. of the water falling in the catchment area, by allowing for various losses enumerated below:—

(1) The evaporation and absorption in the catchment area which, excluding the lake, equals 1095·5 acres, was calculated upon the basis of a "handicap" of 30 inches on the annual rainfall which in 1925 was 98·48 inches. It will be noticed that by adopting this figure, the run-off from the area works out at about 70 per cent., *i.e.*, 119,300,000 cubic feet.

(2) The evaporation losses from the lake at, say, 5 feet per annum amount to 26,245,000 cubic feet.[1]

(3) For losses from the lake by springs, the figure taken was 425 gallons per minute, being the mean of two previous estimations by Messrs. West and Hoey: these came to 36 million cubic feet.[2]

(4) The water taken for Municipal purposes and for Government House, during 1925, was 6 million cubic feet.

(5) The power-pipe discharges, as obtained from the Annual Report upon the Hill Sides around Naini Tal, equal 31,220,000 cubic feet.

(6) The discharge through the sluices and overflow (the figures being obtained from the same source as 5) amounted to 106,747,000 cubic feet.

Taking into account the correction for difference in lake level (7,191,000 cubic feet), the total water accounted for was 318,321,000 cubic feet. As the rainfall for 1925 equalled 434,691,000 cubic feet, the percentage run-off thus obtained is 73·5 per cent. approximately.

As the figures assumed for evaporation losses from the lake and absorption losses in the catchment area are based upon very approximate data, Messrs Tunnicliffe and Coulson did not think it advisable to take these figures into account in the annual calculations for the run-off. If these figures, accordingly, be neglected, a reasonable figure to expect for the percentage run-off in most years would be in the neighbourhood of 50 per cent. It was thought

---

[1] From a study of available records, Mr. Lyle assesses the annual evaporation from the lake surface as 3 feet 4 inches.

[2] Gaugings of the springs made after the above was written indicate that the probable losses by springs are about 140 million cubic feet of water per annum.

that little reliance could be placed upon the conclusions arrived up to date and future calculations of the run-off should be based upon more reliable data.

In a list enumerating certain additional protective works which were in his opinion advisable, Mr. Coulson mentioned amongst others: the removal of the large rock (Craig Ellachie) which overlooks the East Laggan rock; the provision of adequate drainage facilities on the threatened area in the vicinity of pillars Nos. A1, A2, B2, C2 and D2 on Kalakhan hill and the prohibition of cultivation in this area; the total demolition of Durga Cottage and the sloping-off of the hill-side, followed by afforestation; the drainage of Sukha Tal; afforestation on the slipped areas of Charta and Manora hills.

The rocks south of the fault line, which passes just below Glenlee, dip N. 30° E. at 45°; those north of it dip N. 35° E. at 16°. The rocks in the vicinity of Durga Cottage, therefore, have their maximum dip practically in the direction of greatest slope and less than the angle of slope. Conditions are thus exceedingly favourable for a slip. Great care should be taken of the drainage in the area from Glenlee to Edwinstowe; this region is as dangerous as the "dangerous area" of Sher-ka-danda hill.

The general dip of the rocks forming China hill and to the south-west of China is between 8° and 10° in a S. W. direction. If there were any general tendency to slip in this region, therefore, it would be to the far side of China away from Naini Tal. Shales with an interbedded band of dolomite form the hill; these shales are very well jointed and fractured, the resultant effect of two sets of cleavages. The result is that with water percolating along the cleavage planes and so dismembering the shales, fragments are continually falling. The scarped face towards Naini Tal is thus always tending towards verticality in its upper parts whilst there is an increasing apron of debris in the lower regions.

The safety of the lower end of Naini Tal down to Durgapur depends upon the Ballia ravine and its branches. At present the water in the Ballia flows under control to the Fairy Hall drain and thence onwards its course is free. In the first part of its course, the Ballia is not far distant from the lake fault and its general direction is the same. The dip of the shales forming the eastern slopes of the ravine is usually towards the river and as the angle of dip is generally less than the angle of slope, the conditions tend to instability. On the western side, however, the slates and shales dip

under the dolomite forming the mass of Ayarpatta and the conditions are far more stable. Thus steep slopes on the western side can be far more stable than less steep slopes on the eastern side.

Considerable trouble has lately been experienced on the western side of the Ballia between the Fairy Hall drain and the Coolie Lines drain. The barracks on the level ground above this region have been badly cracked and wisely vacated. Down the scarped face towards the Ballia numerous cracks have appeared in the surcharged revetment walls and a definite line of movement can be made out through the soil-cap of the main spur. Numerous slips have occurred in the lower part of this spur, the net result of which is to leave a scarped face which approaches verticality. The whole area is distinctly unsafe.

Rain-water, as usual, has been the chief destructive agent and the heavy rains of the current monsoon have added their quota of damage to that begun by the preceding rains. The soil-cap has become sodden with water and this has percolated through to the shales beneath. In addition, one of the lines of leakage from the lake exists almost at the junction of the shales with the dolomite at this point. There is thus abundant underground water available to make sodden the rocks of the spur in question. The Ballia also cuts away the toe of the spur and more soil and rocks subside to take the place of the material removed.

The dip of the rocks in this region is about 20° in a direction N.75°W. but whilst this tends to stability, the combined effect of the agents of destruction enumerated above has rendered the natural conditions powerless to prevent a gradual sinking of the spur.

Mr. Coulson did not think it possible to prevent the threatened slip and considers that a burst of three or four days heavy rain will bring about the fall of the bulged soil-cap and probably parts of the spur as far back as behind the first godown. When the slip has taken place, new revetment walls should be built and the flow of the Ballia and the Fairy Hall drain adequately controlled.

The Durgapur Power House was built upon the debris of the 1898 landslip from Kalakhan hill, already described by Mr. Middlemiss.[1]

Though the landslip foretold by Middlemiss has not yet taken

---

[1] Report upon the Kalakhan Landslip near Naini Tal, Government Press Calcutta, 1898.

place, the natural conditions are of great instability. The rocks of this region are very cleaved and shattered but the main cleavage direction seems to be towards the Ballia and the dip slightly less than the angle of slope. With the Ballia continually doing damage at the toes of the spurs, the conditions are ideal for a big landslip to occur. All that seems feasible is to take such preventive means as are possible to delay a slip which is probably inevitable and which will cause great damage when it does happen.

Charta hill was the scene of a destructive landslip on the 29th September, 1924, and the present trouble is in brief due to the difficulty in controlling the water flowing over the 1924 slip debris. Recent wash outs of debris have revealed rock *in situ* in the upper part of the main stream-course but its dip is not calculated to lend strength to the foundations of any proposed wall across the ravine in this region. In addition, the regions in the vicinity of observation pillars Nos. 1, 2, and 11 will shortly fall and cause destruction to the uppermost retaining wall. The whole site of the Brewery settlement is far from safe. Mention has already been made of the probable fall from Kalakhan hill; in addition, the spur of Charta to the south-west of the settlement is known to be conspicuously cracked. The spur between the Durgapur and Charta hill streams is far from safe and the spur overlooking the bridge on the Ranikhet side of the Ballia has recently cracked.

The subsiding area in the Depôt Road is in a valley between two small spurs of Kalakhan. Provided that adequate means are taken to prevent water entering the subsiding area at the fracture zone and in other places, Mr. Coulson thought it quite possible, though not of course certain, that further subsidence could be prevented.

Near mile 9 on the Kathgodam-Naini Tal road, much money has been spent upon constructive works to prevent further subsidence of the road but up to date, efforts have been unavailing. Mr. Coulson has described the geological conditions in this Amparao area in detail and has shown that though the argillaceous rocks at the main slip dip into hill "3,300" at about 7° in a direction N. 50°W., their physical characters are such that slips must take place. He also notes the existence of two faults in the area which have highly fractured the rocks and decreased their stability. The slipping surface is presumably the surface of the argillaceous material below the debris which is still *in situ*; this is kept lubricated

chiefly by percolation of spring water derived from rain falling upon a cultivated area behind the hill and water from several stream courses which pass over the cultivable area.

Provided that certain methods of drainage suggested by Messrs. Lyle and Coulson are followed and all cultivation stopped, it is thought that the slip may possibly heal itself in time if the main wall holds. Mr. Coulson did not think it possible to take the road higher up the slip face since sound foundations were not obtainable there. He also thought the expense of taking the road behind hill "3,300" would be prohibitive and it would add greatly to the length of road between Naini Tal and Kathgodam.

Mr. Coulson inspected a rough proposed alignment of the road on the other side of the Nalena river, and thinks that a road here is undoubtedly feasible, in spite of the fact that geological conditions are very similar to the Amparao side, except that on the Nalena side the rocks dip at higher angles than those on the Amparao side. There are thin bands of argillaceous shales interbedded with sandstone bands which will to a certain extent act as buttresses, but should surface water gain access to these argillaceous bands, it is quite possible that the history of Amparao may be repeated. Geological conditions across the Nalena were thought to be insufficiently favourable to warrant the abandonment of the present road and the latter should be maintained at least until proper drainage methods have been tried and found unavailing in the region above Amparao.

Garnet.

North Arcot district : Madras.

Garnets are described by Mr. Vinayak Rao as plentiful in the gneiss one mile north of Kannamangalam (12° 45′ : 79° 9′ 30″ Survey sheet 57 P/1) in the north Arcot district of Madras, and might be useful for abrasive purposes.

Gems.

Mogok district : Burma.

Historical records of gem-mining in the Mogok district of Upper Burma date from 1597 A.D., though the industry must have been in existence for a long period before that time. The Stone Tract was treated as a private estate of the Burmese Kings. A race of heriditary miners had evolved there and the methods of the Burmese administration, modified in accordance with the principles of equity, formed the foundation

on which the Upper Burma Ruby Regulation of 1887 was laid down, and on which the original lease, issued in 1889 to the Burma Ruby Mines, Ltd., was framed. The main features of this lease still persist. The interests of the indigenous ruby miner were fully safeguarded under the British regime. Licenses to win gems are granted to descendants of the old families and land for the purpose is allotted to them as occasion arises. For some years the company collected and retained the license fees, against which it paid a fixed rent and a proportion of its annual profits to Government, but since 1909 the royalties collected by the company have been accepted by Government (less 10 per cent. commission) in place of the fixed annual rental.

For some time the ruby market has been in a state of severe depression, and in 1925 the Burma Ruby Mines, Ltd., went into voluntary liquidation, after a chequered career of over 36 years. At the request of the Government of Burma, Dr. Coggin Brown visited Mogok in December last to investigate the situation and to make suggestions for the future development and control of the industry. He has submitted a report in which the history of the company, its financial affairs and its relations with Government on the one hand and the native miners on the other, are ably traced in detail, from the annexation onwards. Especial attention is paid to the technical progress which has been made, to the growth of modern methods of gem-mining, to the causes of the depressions which have periodically upset the market and to the competition of artificial gem stones.

Another part of the report deals with present and future mining operations by native methods, and contains recommendations regarding the following matters:— the issue of licenses, the restrictions limiting mining to an hereditary class, the liaison between the local authorities and the company, the complaints of native miners regarding the prohibition of explosives and machinery, tributing, the reservation of areas for the company, illicit mining, the curious local custom of *kanase*—by which women and girls enjoy the right to remove gems from stream-beds, tailings, races, and mine and washery dumps without the payment of fees—and finally, to the question of the staff which must be created to supervise native mining in case the Company expires.

The concluding section of the report deals with future mining operations by up-to-date methods. The present condition of gem-

mining in Burma is due to the cumulative effect of numerous adverse causes, but exhaustion of the gem-bearing deposits of the Mogok Stone Tract, as a whole, does not, in Dr. Coggin Brown's opinion, constitute one of these. The tract and the leased area extend over more than 600 square miles, the greater part of which is occupied by gneisses and associated rocks of Archæan age. Traversing them are great bands of crystalline limestone which stretch from the eastern bank of the Irrawaddy to beyond the longitude of Mogok. The sizes and positions of the more important of these have been demarcated on LaTouche's map of the Northern Shan States as far as a geological survey on a scale of one-inch-to-one-mile can exhibit them. A larger survey would probably reveal more of these limestone bands. From them most of the precious and semi-precious stones, and all the rubies and spinels, have been derived. (The sapphires, for which a brisk demand exists to-day appear to come from another source—a rock which may be of pegmatitic origin but which still has to be studied.) Their weathered products, released as the parent rock decays, travel down hill to the stream beds where they accumulate in the water-borne gravels. It follows from the existence of gems in such situations that they must of necessity occur also in the detrital deposits of the hill-sides from which the true alluvials have been derived. The operations of the present Company, apart from early abortive attempts to mine gems from the limestone and a few inconclusive experiments on certain hill slopes, have been confined to removing and washing gravels from the Mogok, Kyatpyin and Kathe valleys. The actual system adopted is due to the work of Mr. A. H. Morgan who solved the drainage problem and so enabled the deeper deposits of the Mogok and other valleys to be treated on a large scale. There are, however, other valleys in the Stone Tract, in particular those of the Kin and Khabine, in which gems are known to occur, and which deserve fuller exploration than they appear to have received hitherto, with the object of proving their value as hydraulic mining propositions, rather than as areas to be opened up and mined by laborious, costly and slow hand methods. It was not until comparatively recent times that the present system of breaking down the working faces with monitor jets and raising the material so obtained by hydraulic elevators or gravel pumps superseded the older system. About the same time the rotary pans of the washing mills appear to have given place to modified forms of sluice boxes,

The greatest possibilities for the future, however, are believed to lie in the large scale treatment, on these lines, of the hill-side deposits and a stretch of country usually known as the "Western Slopes," in Dr. Coggin Brown's opinion, first merits attention. It is a somewhat indefinite area lying on that side of the ranges between Bernardmyo and Kathe which, judged by the amount of mining performed by natives in the past, is a gem-bearing region of great extent. It is stated that large parts of it could be reached by the cutting of the Bernardmyo ditch, a water channel surveyed under Mr. Morgan's direction in 1924.

Suggestions are made as to the new form of lease which should be substituted for the old one in case these or similar operations are undertaken in future.

Gold.

Lower Chindwin district : Burma.

A minor industry in gold-washing is reported by Mr. B. B. Gupta to be carried on in the rivers of the Lower Chindwin district, Burma, flowing from the Paukin Chaung and draining areas covered by Irrawadian deposits. The villages of Pauktaik (22° 10′ ; 94° 47′ 30″), Thaminthat (22° 15′ ; 94° 45′ approx.), Zibindwin (22° 16′ 30″ ; 94° 50′ 30″ approx.), Tuywa (22° 24′ ; 94° 47′ approx.), and Nyaungbinle (22° 20′ ; 94° 39′ 30″) may be mentioned as places where gold-washing is carried on after the monsoon. The industry dates back to before the time of King Mindon. The daily output for each party of two or three men varied from ⅛th to ¼ *tola* by weight of gold (nearly 22½ and 45 grains, respectively).

Gold has previously been reported from Kani (Burma Gazetteer, Lower Chindwin District, p. 116 ; *Rec., Geol. Surv. Ind.*, Vol. XLIII, p. 250). Mr. Gupta did not hear of gold being actually washed at Kani but notes that the produce from the localities noted above passes through this village.

Salem district : Madras.

Auriferous quartz was reported to have been found at Matagondapalli (12° 37′ 30″ ; 77° 44′) about ten miles south-west of Hosur in the Salem district of Madras, where the rocks consist of the older gneisses intruded by the Hosur gneiss of Mr. Middlemiss, with included fragments of hornblende schists and some dykes. An assay in the Geological Survey laboratory of some of the quartz from this area, however,

showed no trace of gold. The chances are against the finding of gold quartz in this area.

Iron.

Keonjhar State: Bihar and Orissa.

Several deposits of good hæmatite, derived from the banded hæmatite quartzite, were mapped by Dr. Krishnan during the season in the Feudatory States of Bihar and Orissa. Some of the best deposits are found along the Bonai-Keonjhar boundary.

The shales of the Iron Ore series in Keonjhar State yield, through weathering and segregation akin to lateritization, lumps and pockets of iron and manganese ores. Dr. Krishnan remarks that these are of irregular, but fairly wide, distribution. The ores are of a rather low grade, but experience in the adjoining area shows that they can be worked on a small scale.

Northern Shan States: Burma.

Ironstone mining in the northern part of the Federated Shan States is carried on by the Burma Corporation Ltd. and the ore so obtained is used in the blast furnaces at Namtu to assist in the reduction of sulphide ores containing lead, silver, zinc and copper. For this purpose they are essential, so that although the quantities raised are small in comparison with those won in India to supply iron and steel works, the industry in the Shan States is a settled and important one and is likely to continue so for many years to come.

Early in 1927 Dr. Coggin Brown was requested by the Government of Burma to review the iron ore situation generally, and to pay especial attention to the questions of extension of known deposits and the possible occurrence of new ores, for it is desirable that the iron ore reserves should bear some comparable relationship to the very large quantities of metallic sulphides which have been proved to exist in the great Bawdwin deposit. He has examined the Manmaklang mine and the various workings centred around Pauktaw and Naungthakaw in the Wetwin region and, in a detailed report on these deposits, has briefly summarized our knowledge of other outlying ones, thus bringing up to date the observations of Messrs. P. N. Datta, T. D. LaTouche, E. L. G. Clegg and his own earlier work on this subject.

The Twinnge deposit was probably mined in the time of the later Burmese kings but Mr. P. N. Datta was the first geologist

to draw attention to the occurrence of iron ore in this neighbourhood (21° 57′ : 96° 25′) (Genl. Rep. *Geol. Surv. Ind.*, 1899-1900, pp. 121-122). In 1916 Dr. Coggin Brown concluded that the ore was of a residual nature and represented the ferruginous material originally disseminated through that portion of the limestone which has been removed by denudation since the Shan Plateau permanently emerged from the sea in later Mesozoic times. Further experience confirms these views (*Rec. Geol. Surv. Ind.*, XLVII, pp. 137-141).

The Manmaklang deposit lies in latitude 22° 50′, longitude 97° 40,′ and was described by Mr. E. L. G. Clegg in 1922 (*Rec. Geol. Surv. Ind.*, LIV, pp. 431-435). Dr. Coggin Brown does not accept the earlier opinions of the geologists of the Burma Corporation that it is of a residual origin, but regards it as a replacement deposit, the result of the action of iron-bearing waters of meteoric origin moving downwards through an exceedingly brecciated variety of the Plateau Limestone. Although Manmaklang still produces from 1,300 to 1,500 tons of limonitic ore per month, it is rapidly becoming an underground proposition in which operations cannot be carried on profitably in competition with surface work on the true residual deposits elsewhere.

The Kunghka ore body (23° 13′ : 99° 19′) is said to lie in a fault zone traversing rocks of the Pang-yung series and to have been formed by the infiltration of iron-bearing solutions, resulting in the production of solid hæmatite in a soft matrix of red and yellow limonite carrying specularite and barite. The Kunghka hæmatite is still mined and used in the production of copper matte only.

All the deposits of the Wetwin region are, in Dr. Brown's opinion, of residual origin. The Pauktaw quarry is close to the main railway line, some 4½ miles south-west of Wetwin station in the direction of Maymyo and about ½ mile from the log-washing plant of the Corporation. It was worked in 1920 and 1921. Originally the iron ore cropped out at the top of a small hill and as it was followed down, the excavation gradually increased to a depth of 35 to 40 feet. Abandoned now on account of the increasing thickness of overburden it still displays faces of red earth with shots of iron ore in its lower layers which overlie an ore bed 8 to 10 feet thick, massive in parts but more commonly possessing an "organ-pipe" structure. Bulk samples of this ore averaged from 56 to 57 per cent. of iron.

The abandoned workings of Bawhlaing lie some two miles to the north-north-east of Pauktaw camp and from them approxi-

mately 200,000 tons of good massive ore have been removed. It was a shallow deposit lying on the top of a limestone knoll showing the usual form of weathering. A typical analysis of the Bawhlaing ore shows iron 56·6, alumina 3·7 and silica 2 per cent.

Active work is to-day being prosecuted on the Naungthakaw lease, which is situated about latitude 22° 10′ and longitude 96° 31′, in sheet B.12 of the one-inch-to-one-mile survey, and six miles as the crow flies to the north-west of Pauktaw camp. It is on ground which slopes gently towards the valley of the Shwe-leik-ka to the south; to the west is the higher land, attaining elevations of over 4,000 feet along which the boundary between the Mandalay district and the Federated Shan States runs. The lease is divided into a number of separate sections. In section A the workable ores occur between 3,650 and 3,700 feet above sea level, varying from thin bands a few inches thick in the north-west and south-east to richer stuff, several feet thick, distributed in three well-defined patches in the middle of the southern half of the area. The average thickness of the overburden in an open cut is about 8 feet, and under this is 6 feet of vesicular hæmatite. In Section B, the best part of the ore bed lies on and about Kadut Taw hill (elevation 3,780 feet). Thinning out down the slopes, it becomes very evident again in Section C at heights of between 3,660 and 3,740 feet, with extensions into Section D. Much of the ore in these blocks is roughly rounded, rubbly material, rather than the cemented solid ore of Section A. The Corporation's Engineers estimated the original contents of Sections B, C, and D at 35,000, 50,000 and 6,700 tons respectively: these figures do not, however, include the whole of the ore bodies but are governed by the economic factors involved in profitable extraction by prevailing methods such as depth of overburden, thickness of the ore band and quantities of injurious compounds like silica and alumina.

An ore bed which commences in Section L and stretches across Section E at much the same contour levels is believed to contain some 35,000 tons. The open cuts display an extremely irregular surface of the underlying limestone, in the deep and narrow hollows of which pockets of brittle, rubbly hæmatite lie under 6 to 8 feet of overburden. Section M contains the southern portion of an ore bed which obtains its greatest development in Section I. Together they have been estimated to contain 66,000 tons. The overburden ranges up to 12 feet in thickness and the greater part

of the ore lies about the 3,700-foot contour. Details of the occurrences in the remaining sections are given in Dr. Brown's report.

Exploitation commenced in 1922, since when 35,000 to 40,000 tons have been removed *per annum*. All the work is opencast, large areas being stripped of overburden and the ore bed systematically removed. The larger pieces are hand picked, whilst the remainder is dry-screened on the spot, carted to Pauktaw, cleaned in a log-washing plant there and railed to Nam Tu. Operations are suspended during the rainy season. The washed ore as railed contains approximately :—

FeO :—71 to 72·5 per cent.
Al_2O_3 :—3·3 to 3·5 per cent.
SiO_2 :—4 to 5 per cent.

The Corporation is engaged in a prospecting campaign in the surrounding country and as there are few surface indications of ore beds it is necessary to pit systematically across likely areas. Beyond advising the intensification of the pitting operations and an extension of preliminary pilot holes towards the north-north-east, Dr. Coggin Brown had no suggestions to make. As about 200,000 tons have been added to the available reserves as the result of the season's work, the present policy appears to be justified.

The prospects of obtaining large additional supplies in the embayment of the Plateau Limestone, covering a triangular area of about 420 square miles, with its base on the railway line between Maymyo and the Gokteik Gorge and its apex on the peak Hpataunggyi (3,564 feet) in Monglong, have been discussed by Dr. Coggin Brown. He believes that the origin of the red earth mantle can only be attributed to the accumulation of the insoluble matter in the limestone itself in the course of its degradation through weathering. If the red earth is a residual deposit its iron contents are also of the same origin. At one time disseminated in small quantities through the parent rock they were at first probably equally well distributed through the red earth, and their concentration into irregular beds towards the base of the clay is due to subsequent processes which have taken place in it since its formation. There are no signs that the iron ore formed any kind of concentrated deposit in the limestone, neither are there the slightest indications in this type of residual deposit that it is of swamp or lacustrine formation, or has been produced by any known kind of

replacement. It follows therefore that iron ore beds should be found in many suitable places both in this particular embayment and on the plateau generally, but the depth of the red earth must be sufficient for the chemical reactions which have resulted in the concentrations to have occurred, and the topographical conditions such that they have not been removed at later periods.

In 1915 Dr. Coggin Brown predicted the occurrence of ore between Wetwin and Padaukpin. It has been proved to exist but is of too bauxitic a character to be of any value in lead smelting. For some reason, which cannot be explained at present, the ores from the lower parts of the plateau and also the pisolites which frequently occur in the upper layers of the red earth, are often highly aluminous and it is to the higher geographical horizons and well drained gentle slopes at elevations such as those indicated that future attention should be directed. A zone of country possessing these features runs almost completely round the embayment, and it is in this, not far from the boundaries of the older rocks and yet not too close down towards the badly drained central area, that further extensions of these iron ore beds will be located. Such iron ore deposits are exceedingly irregular. The exhausted portions of the Naungthakaw blocks show how variable the surface of the underlying calcareous rocks may be. The general impression that it is a more or less level underlying table is entirely wrong for it is weathered into fantastic heights and hollows. One prospecting pit may miss the ore bed entirely, while the next one, landed on a hole in the limestone full of ore, may make an excellent and misleading showing. Close and careful pitting is essential before estimates can be attempted, while lines of pits should not be stopped because one or two holes yield poor results in succession. Instances are known in which a good ore sheet has thinned away to practically nothing down towards an insignificant surface drainage channel, to make again in quantity on the opposite slope.

Thaton district, Lower Burma.

Mr. P. Leicester was deputed to investigate the reported occurrence of rich deposits of iron-ore near Mokpalin in the Thaton district of Burma. The area, over which a prospecting license has been applied for is shown on the Survey of India $\frac{1}{4}$-inch sheets 94C and 94G. The claim lies in the foot-hills of the Kyaikto ridge east of the Sittang River in the Thaton district, and the area which has been prospected is about fifteen miles to the north-east of Mokpalin, a station on

the Moulmein branch of the Burma Railways, 80 miles from Rangoon. Only part of the area under consideration had been geologically surveyed; this had been done by Mr. P. N. Datta in the Field Season of 1908-09.

In passing north-eastwards from the sea up to the Kyaikto range the following rock series is traversed:—

Alluvium.

Laterite.

Thaton series (sandstones and shales).

Igneous rocks:—

Volcanic: Volcanic agglomerate.

Plutonic { Granite. Contact-altered basic rock, Epidiorite and talc schist.

Gneiss.

The sedimentaries of the Thaton series are covered with a thick cap of laterite in the neighbourhood of the coast but farther to the north-east there are frequent exposures of sandstones and shales with a general strike N. 20° W.—S. 20° E. and steep variable dip.

About six miles north-east of Mokpalin is a ridge known as Kyaukpon Taung, running N. 20° W.—S. 20° E., showing exposures of volcanic agglomerate. The stratigraphical relations of this rock are obscure but Mr. Datta[1] mentions "volcanic rocks, probably rhyolitic" as occurring in this ridge. The association of agglomerates and tuffs with rhyolite is a most natural and probable occurrence.

Mr. Leicester considers that the talc schists, which occur in various localities within the area, are probably derived through the alteration of basic or ultra-basic rock. Microscopic examination of the rock reveals talc with numerous small grains of magnetite partly decomposed to hæmatite.

There is a considerable area consisting of green metamorphosed basic rock and it is in this rock that the iron-ore occurs in the form of segregations of magnetite in irregular lenticular ore-bodies or lenses, which probably tend to run in a direction parallel to the granite contact. This rock appears to have been intruded as a basic product of differentiation from the parent magma of the granite of the Kyaikto ridge.

[1] General Report for 1910, *Rec. Geol. Surv Ind.*, Vol. XL, p. 108.

Dr. L. L. Fermor examined certain specimens and microscope slides of the basic rock submitted by Mr. Leicester and came to the conclusion that the original rock was probably an augite-plagioclase rock, possibly a gabbro, and considers that the green metamorphosed rocks may be classed as epidiorites.

Two occurrences of ore *in situ* have been discovered by the prospectors. These comprise rich segregations of magnetite about thirty feet in width with a general trend N. 20° E.—S. 20° W., but as yet no attempt has been made to discover the extent and true direction of the ore-bodies.

Elsewhere numerous pits have been sunk through the talus and soil-cap of the hill slopes. These pits have in many instances yielded detrital fragments of rich ore which have been derived from ore-bodies probably situated higher up the slopes.

The amount of proved ore is small but systematic prospecting should not only reveal the extent and nature of the occurrences already found but should also disclose some at least of the ore-bodies which are the source of the detrital fragments of ore scattered over the region. According to Mr. Leicester it seems probable, from the structural geology of the neighbourhood, that the ore-bodies are lenticular and that they run approximately parallel to the granite contact in a roughly north and south direction.

The ore is not in the form of veins or lodes and there is no indication of its having been thrust up into or having formed in fissures. It occurs, as has already been mentioned, in irregular, lenticular ore-bodies or lenses, originating apparently by concentration and segregation of the iron in the basic parent rock. This implies that the ore-bodies will in all probability be very irregular and of uncertain depth and their underground extent can only be accurately estimated by boring. The whole is capped, except in the stream-courses, by a considerable overburden of soil, laterite and talus which besides adding to the difficulty of prospecting will increase the cost of its extraction.

Lower Chindwin district, Burma.

Mr. Sondhi reports that in the neighbourhood of the village of Natyin Daung (Sheet 84 J/14) the Plateau Gravel is remarkably rich in round, hollow, ferruginous concretions, which appear to have been worked for iron by the villagers not long ago. Slag heaps were occasionally encountered during the course of the examination of the area, but active work has been discontinued.

North Arcot district: Madras.

Bands of Dharwars with magnetite were noticed by Mr. Vinayak Rao at Sottukinni (Survey Sheet 57 P/3) in the north Arcot district of Madras.

Manganese (see also Iron—Bihar and Orissa).

Kanara district: Bombay.

The manganese deposits of the Kanara district of Bombay were further investigated by Rao Bahadur M. Vinayak Rao, who reports a great development of manganiferous laterite in the neighbourhood of Castle Rock, extending some distance to the south. Manganese is found replacing some of the Dharwar quartzites at the Bhagavati mine about 2 miles south of Castle Rock.

Manganese is found in the laterite about 3 miles west of Anmod on the road to the Portuguese frontier.

To the south and south-east of Castle Rock manganese has been noticed east of Ku Vesi and in the hill between Kesarla and Titvali.

Psilomelane, pyrolusite and wad are usually the forms of manganese met with in this area. An analysis in the Geological Survey Laboratory of the Titvali manganese showed as much as 51 per cent. of manganese.

Belgaum district; Bombay.

In the Belgaum district manganese occurrences are chiefly confined to the south-west part of the Khanapur Taluk. They occur in the laterite over the Dharwars which here have an rregular north and south direction. The chief places where workable quantities are found are: Talevadi, Amgaon, Jamgaon, Nerse and Kumbharda near Nagargalli.

The ore occurs as a replacement mineral in laterite and occurs irregularly in blocks thereof. In Talevadi it is present below the laterite on top as well as in the valleys where a detrital laterite is found. It is also found segregated as thin bands along the stream-courses. Wad or the powdery form is found on the hill at Jamgaon, where it occurs as a fairly thick deposit of about 2-3 feet in thickness. In Jamgaon and Amgaon blocks of manganiferous laterite are found along the river valleys.

The laterite on hill-tops due to the alteration of Deccan Trap does not appear to have any manganese.

Mica.

Mr. G. V. Hobson, whilst on study-leave in the United States of America, took the opportunity of making some enquiries regarding

mica, its distribution, utilization and consumption, and has submitted an interesting report upon the subject. Mr. Hobson was led to the conclusion that the mica-broker or middleman, although necessary to the trade, was absorbing a very large portion of the profits—a proportion sometimes well over one hundred per cent. This conclusion is confirmed by the surprisingly low average price obtained by the exporter of mica from India. The value for the years 1922, 1923, 1924 and 1925 averaged little more than Re. 1 per lb., the rupee at that time having an exchange value not far from 1*s.* 4*d.*

Mr. Hobson concluded that the elimination of the broker was only possible in the case of very large producing and consuming firms. One American firm has already achieved this result. The necessity of the broker arises from the fact that while the producer has for sale all sizes and grades of mica, the consumer in most cases requires only one or perhaps two sizes of one particular grade. This means that the producer, in order to dispose of his whole output, must be in touch with consumers of all classes, and must be prepared to carry heavy stocks. The producer is, in fact, very much in the hands of the broker, and frequently has to accept the price the broker offers him. Any producer attempting to do without the broker with respect to one or more sizes or grades of mica runs the risk of being boycotted by the broker with respect to the rest of his material.

One of the complaints made to Mr. Hobson regarding Indian mica was that occasionally a few cases of an order were found to contain mica of a different size from that ordered. The excuse made by the exporter would be that, owing to shortage, a case or two had to be filled with undersize mica and, to make up the average, a case or two filled with oversize mica. An examination of the consignment, however, always showed a balance in favour of the exporter. Another complaint was that Indian firms occasionally went back on their quotation and, on the receipt of a repeat order, attempted to raise the price. Mica consumers do not carry very large stocks and have no time for bargaining. Such correspondence as the above, therefore, usually meant a placing of the order elsewhere.

Mr. Hobson remarks upon the increased use of micanite, which is gradually replacing block mica in a number of uses. Two of the latter seen by Mr. Hobson were in the form of heater-units for

electric irons and lamp shades. Micanite is made from splittings, the production of which is at present almost a monopoly of India. In Schenectady Mr. Hobson was shown the latest development of the manufacture of micanite by machinery. Here mica-plate is being made with a new synthetic resin, which may prove a serious rival to the shellac hitherto used for binding purposes and derived from India.

During a visit to the Lacey mine in Ontario, the largest phlogopite mine in the world, Mr. Hobson was impressed with the efficiency of modern machine drilling and deep hole blasting. As the mica within the Indian pegmatites is much more scattered and the danger of damage to the mica correspondingly less, such methods should be eminently suitable for exploitation in this country. Skill is required in determining the blasting charge necessary to break the ground without shattering it.

There is undoubtedly a tendency towards the greater utilization of mica for almost any type of insulation problem. Micanite tape, flexible micanite, moulding micanite, heat-resisting micanite, etc., can be used for such purposes, except where the insulating material must be poured into position.

Considerable efforts are now being made in South Africa and other countries to market a better dressed and graded product, and should this be accompanied by the training of the cheap labour available in the art of making splittings, the Indian position in the trade would to some extent be threatened.

Monazite.

Jeypore Estate; Madras.

Mr Vinayak Rao noticed grains of monazite in the natural concentrates formed by the river Kalab, Jeypore Estate, Madras. As the area drained consists mostly of charnockite, it seems probable that the monazite was derived therefrom.

Petroleum.

Lower Chindwin district; Burma.

Mr. B. B. Gupta, while surveying in the Lower Chindwin district of Burma, noticed a seepage of oil about half-a-mile north-west of Nyaungbinle (22° 20′; 94° 39′ 30″) in the Pondaung sandstone close to the faulted boundary. Two other seepages were noticed in the

neighbourhood and though not active at the present day there can be no doubt that they were so at no remote period. One of these seepages is understood to have been tested by a trial boring without any favourable result.

Pyrites and Pyrrhotite.

North Arcot district; Madras.

The pyrites deposit of Polur in the North Arcot district of Madras, mentioned on page 50 of the Records of the Geological Survey of India, Volume LX, page 50, was further opened up by Field-Collector A. K. Dey during the field-season 1926-27. The pyrites occurs in lenticular bands between basic charnockites and quartzites of presumably Dharwar age, and is associated with a pegmatite. The width is about 4½ feet but is variable. Pits put down to a depth of 13 feet showed no diminution in width. Pyrrhotite was found in association with the pyrites which has been transformed into limonite at the surface and sides. Opal was found as a thin film on the surface of the pyrites, concentric in shape, showing secondary deposition at the surface.

An analysis of a sample of the pyrites in the Geological Survey laboratory, made by Field-Collector Dey, gave the following results:—

SiO_2	17·28
Al_2O_3	8·72
Fe_2O_3	17·32
Fe(sulphidic)	31·06
Ni	Trace
MnO_2	Trace
MgO	1·02
CaO	·98
SO_3	0·91
S	20·16
K_2O	·18
Na_2O	1·38
H_2O +	1·40
H_2O	·52
	100·93

This analysis and the one made by Mr. V. S. Rajagopalan (Sec. *Rec. Geol. Surv. Ind.*, LIX, p. 50) give about the same amount of sulphur. The pyrites deposit occurs in lenticular patches and is likely to continue in depth.

Refractories.

During the field season, Dr. J. A. Dunn made an examination of several deposits of aluminous refractories in Northern India, with the object of obtaining some idea as to the resources available in the country. During the last few years the minerals sillimanite and kyanite have been found to possess a particular value as refractories in the ceramic industries. It has been found that, on heating, these minerals change to a material called mullite ($3Al_2O_3.2SiO_2$) and a peculiar glassy material, in part cristoballite, the former occurring as an intricate network of lath-shaped crystals in the latter. If free Al_2O_3, *e.g.* corundum, is present, there is a greater amount of mullite developed relative to the glassy base. The resulting composite material has a rather low coefficient of expansion, high melting point, and considerable strength at high temperatures. Its peculiar properties render it ideal as a refractory material. So far as is known India possesses far greater resources of the minerals sillimanite and kyanite than any other country.

Assam.

The deposits of sillimanite and corundum in Assam occur in the neighbourhood of Sona Pahar north of the village of Nongmaweit in Nongstoin State. The area may be reached by motor lorry from Gauhati, 36 miles west as far as Boko, thence 12 miles south by bullock cart to Haima at the foot of the Khasi Hills, and finally some 2 days' march south into the hills for 23 miles. The area is on the Khasi Hills plateau and the height above sea-level is about 3,000 feet.

The sillimanite-corundum deposits are associated with such highly aluminous rocks as cordierite-biotite-quartz-microcline-gneiss and sillimanite-quartz-schists. The majority of the deposits consist mainly of massive sillimanite with a little corundum; one or two are almost entirely of corundum and several are entirely of sillimanite. Impurities are not abundant and consist mainly of rutile, a very little biotite, and iron ore. There are some thirteen different deposits occurring over a belt some 3 miles long by 1 mile wide. It is quite likely that the belt extends over a greater length than that surveyed.

In estmating the quantity of material available it is difficult to arrive at any definite quantity, owing to the peculiar "segregatory" nature of the individual deposits, and to the fact that a very large amount of the material is completely decomposed. However, reckoning down to a depth of only 10 feet for the majority of the

deposits, Dr. Dunn estimates that there is at least a total quantity of 83,000 tons available, including float ore. This must be regarded as an absolute minimum; the actual quantity could easily be many times this amount.

In judging their economic value the location of these deposits is a grave disadvantage, and under present conditions transport difficulties would make freight high.

Rewa.

The deposit of corundum-sillimanite in Rewa State, Central India, is near Pipra, a small village in the extreme south-east corner of the State, about 5 miles from its eastern and southern boundaries. The deposit is associated with sillimanite schists and pyroxene-bearing rocks. The bed of corundum is about half-a-mile long by about 70 yards wide. Reckoning on an average depth of 30 feet, the total quantity of corundum available was estimated by Dr. Dunn to be at least 100,000 tons. Of sillimanite the estimated quantity is 1,000,000 tons of very poor quality, with perhaps 100,000 tons of good material. The possibility of exploiting the better class sillimanite is, however, limited owing to its intimate admixture with the impure material. Apart from this latter fact, however, there is the additional disadvantage of the very high freight to Calcutta. At present it is carried by bullock pack to Mirzapur, some 120 miles. Transport costs could be considerably reduced by constructing a bullock cart track to the bank of the Son River, whence the material could be floated down the Son and Ganges Rivers on barges.

Bhandara; Central Provinces.

The deposit of corundum and sillimanite in the Bhandara district of the Central Provinces is at the foot of a small hill about 1 mile south-east of Pohra village. This village is 3 miles as the crow flies south-south-east from Lakhni, which is 13 miles east of Bhandara town and on the main road. The hill is formed of a N.-S. striking bed of quartzite which dips to the west at a high angle and is flanked on either side by sillimanite-bearing muscovite-schists, the muscovite varying from merely an occasional constituent to the dominant mineral in the rock. Another rock-type associated is a fine-grained tourmaline rock usually containing sillimanite needles and traversed by veins of sillimanite. The massive sillimanite is found associated with this tourmaline rock, usually as veins or as irregular replacement masses up to 6 feet across. Such massive sillimanite was found only by Dr. Dunn at one point *in situ*, over an area of 40

feet by 50 feet, but debris indicates, perhaps, a wider distribution. The massive corundum was not found *in situ*; all the corundum now being obtained is found in the hill-wash at the north foot of the hill over an area of 100 by 100 yards. Dr. Dunn considers the deposit to be negligible since the amount of ore cannot exceed more than 100 tons each of corundum and sillimanite.

Barabhum ("Barahabhum"); Bihar and Orissa.

In the neighbourhood of Rengadih near Barahabhum Station on the Purulia-Sini branch of the Bengal-Nagpur Railway, several occurrences of kyanite rock are found over a narrow east-west belt extending from about ¾ mile east of Salbanni to just south of Ichadih, a total length of about 7 miles. The rock with which the kyanite is associated is a mica-schist, occurring along the boundary of the Chota-Nagpur granite-gnesis. Indeed, some of the kyanite-rock was found to occur in mica-schist which is included in the granitic rock itself. The mica-schist is a pure muscovite-quartz-rock. Another associated rock is tourmaline-quartz, frequently banded, and often so riddled by white quartz that it has almost the appearance of a breccia. Tourmaline-rock is formed by replacement of the mica-schist. Dr. Dunn describes the kyanite rock as occurring in small irregular masses up to 6 feet in length in the mica-schist. Much of its seems to have been altered to muscovite by crushing and the addition of alkalies, and originally the kyanite-rock was probably far more abundant than now. A peculiar feature is the occasional, but rare, occurrence of crystals of blue corundum in the kyanite rock.

According to Dr. Dunn it is doubtful whether 100 tons of good material could be collected easily, and even if more could be obtained by closer prospecting and greater expense, the value of the material would be discounted by the amount of muscovite present.

Singhbhum; Bihar and Orissa.

There is a series of deposits of kyanite-rock extending over a belt some 70 miles long in the Singhbhum district, Bihar and Orissa, passing through the native States of Kharsawan and Seraikela, and the Dhalbhum subdivision. The main rock of this belt is a muscovite-schist, but hornblende-schist is very frequently met with. The mica-schist often contains large crystals of staurolite and garnet. Dr. Dunn observes that the rock with which the massive kyanite is usually associated is a kyanite-quartz-rock or granulite. At Lapsa Buru this rock is found in enormous beds, the massive kyanite apparently

occurring as segregations in the more acid rock. Very frequently, as a secondary alteration product of the kyanite, a topaz granulite is found. Corundum is a common mineral in the massive kyanite-rock. Rutile, as in all these aluminous deposits of Northern India, is also a constant constituent in the rock. There seems little doubt, according to Dr. Dunn, that these deposits are the metamorphic products of highly aluminous clays, and in some cases apparently of clays of a bauxitic composition.

The largest deposit is that at Lapsa Buru at the western end of the belt. Here, the debris alone would, according to Dr. Dunn's estimate, provide a minimum quantity of at least 234,000 tons of kyanite rock; this, however, is given as a very conservative figure, the actual available quantity being possibly 10 times this amount. Another good deposit is at Ghagidih, about 3 miles south of Jamshedpur, where over 20,000 tons are available.

At Rakha Mines there are perhaps several hundred tons of massive kyanite in the alluvium shed from the kyanite-quartz-rock. In the remainder of the belt to the south-east of Rakha Mines there is little or no massive kyanite-rock associated with the kyanite-quartz granulite, but the latter may find a market, in the future.

Bamra State; Bihar and Orissa.

The mineral from Balram in Bamra State, Bihar and Orissa (see General Report for 1925, *Rec. Geol. Surv. Ind.*, LIX, p. 51), originally thought to be sillimanite has, on closer investigation, proved to be tremolitic amphibole.

Ruby (see Gems).

Salt.

Sagaing district; Upper Burma.

Salt is of common occurrence in the Tertiary rocks of Upper Burma and in the past a considerable industry in salt working was carried on in the Sagaing district. Kadu Lake (22° 3′; 95° 33′) covers some 40 square miles and is a shallow, saline lake. In the past it appears to have extended further to the east and Mr. Bradshaw reports that traces of the old workings are still visible. Low hummocks in the soil-cap east of Padu mark the sites of the debris from the ancient sump holes and the fragments of multi-

tudes of pots are stratified in the soil. Salt is found in the Tertiary rocks which form the hills between Saye and Ondaw, as brine from wells and springs, and as an efflorescence in the sandy deposits which form the low ground. At Padu a tube well was sunk some 100 fee in quest of water for the Agricultural Department experimental farm. Some 1,200 gallons per hour of saline water was obtained and it has been suggested that if the brine content be sufficiently high this water m ght be evaporated for the production of salt. There can be no doubt that the salt is derived from the Tertiary rocks. In the area examined by Mr. Bradshaw there was no active work in progress but in view of the large quantities of salt which are imported annually into Burma, the salt which occurs in this district might prove to be of economic importance if it were worked systematically.

Sandstone (see Building Materials).

Sapphire (see Gems).

Spinel (see Gems).

Sulphuretted Hydrogen.

Lower Chindwin district; Burma.

Springs charged with sulphuretted hydrogen were noticed by Mr. B. B. Gupta in the following localities of the Lower Chindwin district, Burma :—

(1) In the Sonda Chaung about one-and-a-quarter miles south-west of Nyaungbinle (22° 20′; 94° 39′ 30″):

(2) In the small river about one-and-a-quarter miles north-west of Thalauk (22° 15′; 94° 40′ approx.);

and (3) In the Yebowa Chaung, about three-and-a-quarter miles north-west of Kabaing (22° 12′ 30″; 94° 41′ approx.).

Tin.

Amherst district; Lower Burma.

Mr. P. Leicester observes that the tin mined around Mawpalaw Taung (15° 52′; 97° 46′. Sheet 95 E/13) east of Karokpi in the Amherst district of Burma occurs in the lateritic eluvial deposits at the foot of the hill. which is composed of red, buff and white sandstone and banded quartzite associated with shales and micaceous slate. The ore which is chiefly grey cassiterite appears to be derived from small quartz stringers intruded into the sandstones during the period of granitic intrusion of the province. The tin has been concentrated in the eluvium of the hillsides and now appears scattered through the lateritic deposits in the vicinity of the hill.

Water (see also Engineering and Allied Questions).

N.-W. Railway, Rahim-ki-Bazar, Sind; Bombay.

Samples obtained from a ten-inch hand-boring made by the North-Western Railway at Rahim-ki-Bazar, about 33 miles south-east of Badin, Sind, and on the northern side of the Rann of Cutch, were forwarded to this department in connection with a water-supply question for the proposed Bombay-Sind Connection Railway.

These samples were determined by the Curator, Mr. A. L. Coulson, and consisted mostly of sand and *kankar* to about 265 feet with a conglomeratic band between 227 and 229 feet. Below 265 feet clay predominated, and at the bottom of the boring, 377 feet, solid rock was encountered in the form of a foraminiferal limestone and gypseous *kankar* band.

The limestone contains specimens of the *Globigerinidæ* family, but none of them was sufficiently preserved to be recognised generically. Mr. Coulson remarks that in all probability the limestone is Tertiary in age and might be one of the Tertiary limestones of Sind (Blanford. *Mem. Geol. Surv. Ind.*, XVII, pt. 1, pp. 37-66) or of Cutch (Wynne. *Ibid.*, IX, pt. 1, pp. 74-81). Certain of the limestones of Sind die out to the south-west, near the Habb river (Blanford; *op. cit.*, p. 47), and Wynne states (p. 33) it is quite possible that other east and west dislocations, similar to the great fault along the northern face of the Charwar and Katrol range, Cutch, may have occurred along the northern sides of the Kureer and Bela chain and likewise along portions of the sometimes strongly scarped

hills which rise abruptly from the Rann on the northern margin of Cutch.

Samples of water obtained at various depths in the bore-hole were reported by the Chemical Examiner to the Punjab Government to be unfit for human consumption and for locomotives. The results of the tests are expressed in the following table:—

Depth of pipe in bore-hole	55′ 8″	109′ 3″	208′ 7″	344′ 5″
Date sample was obtained	2-1-1927.	6-1-1927.	16-1-1927.	27-3-1927.
Reaction	Alkaline.	Alkaline.	Alkaline.	Alkaline.
Free carbonic acid	Marked.	Marked.	Marked.	Marked.
Chloride as NaCl (parts per 100,000).	2,750	5,265	23,107	21,937
Nitrates	*Nil.*	*Nil.*	Present.	*Nil.*
Nitrites	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Sulphuretted Hydrogen	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Lime	Excessive.	Excessive.	Excessive	Excessive.
Iron	Traces.	Traces.	Traces.	Traces.
Sulphates	Excessive.	Excessive.	Excessive.	Excessive.
Total solids (parts per 100,000)	4,281	7,310	30,730	Excessive.
Hardness (Clarke's Scale) Temporary	70	140	Excessive.	Excessive.
Hardness (Clarke's Scale) Permanent	420	560	Excessive.	Excessive.
Total	490	700	Excessive.	Excessive.
Free ammonia	Excessive.	Excessive.	Not estimated.	Not estimated.
Albuminoid ammonia	Excessive.	Excessive.	Not estimated.	Not estimated.

A bore sunk to a depth of 850 feet at Drig Road, near Karachi (Crookshank, *Rec. Geol. Surv. Ind.*, LX, pp. 157-169), two bores sunk by the North-Western Railway at Dabheji and Jungshahi in the same district, and a boring made in similar rocks in Kathiawar, all proved these Tertiary rocks to be impregnated with saline water. It is not therefore considered advisable that the boring at Rahim-ki-Bazar be continued through the limestone in the hope of obtaining a supply of fresh water.

In the General Report of the Department for 1926 (*Records*, LX, p. 58) it is mentioned that a report on the waterless tracts of the Allanmyo sub-division in the Thayetmyo district was being prepared by Dr. J. Coggin Brown. It is one of a series dealing with the geology of the waterless areas in the dry zone of Burma generally and the prospects of obtaining underground supplies of water by boring within them.

Thayetmyo district; Burma.

The difficulties which beset the question have been summarised in the General Report referred to, and it is only necessary to state

here that they are no smaller in the case of the Thayetmyo district than elsewhere.

The Allanmyo sub-division comprises that portion of the Thayetmyo district which lies to the east of the Irrawaddy river. It is divided into the two townships of Sinbaungwe and Allanmyo. In the former there are three waterless tracts and in the latter nine.

Sinbaungwe Township.—

Tract No. 1.—Tract No. 1 contains the villages, Kyauksauksan with a population of 1,200 souls, Daukhla village, population 80 souls, and Kyaukpyudaung, population 280 souls. These villages lie between 450 and 570 feet, respectively, above sea-level and between five and eight miles directly east of the Irrawaddy, about latitude 19° 45′, in sheet No. 85 M/2 of the one-inch-to-one mile survey of Burma. They all possess tanks which dry up for three months during the hot weather, when water has to be carried from streams one to two miles away. According to the geological map made by Rao Bahadur Sethu Rama Rau in the years 1914-15, the three villages lie on Irrawadian rocks which occupy a wide area hereabouts. There is nothing exceptional in the local structures to lead one to suppose that the possibilities of obtaining underground water at Kyauksauksan or Daukhla are otherwise than doubtful. In the case of Kyaukpyudaung, conditions are perhaps a little better, for rocks of Pegu age, which underlie the Irrawadian series are found one mile to the east of this place. At the same time boring here cannot but be regarded as risky.

Tract No. 2.—Tract No. 2 lies seven miles to the south-east of Kyauksauksan. It contains the villages of Pozut and Pokolon with populations of 280 and 400 souls, respectively. They both possess tanks which dry up in March, when water has to be carried from the Yebon stream three miles away. The local rocks belong to the Irrawadian and boring is not recommended.

Tract No. 3.—Tract No. 3 contains the village of Thittabwe, population 120. It lies in the extreme south-eastern corner of sheet No. 85 M/6 and has an elevation of over 600 feet above sea-level. It is situated between the axes of two well-marked folds in the Pegu rocks but it is doubtful if the expenditure involved in sinking a tube well here is justified for such a small area. The best situation for an experimental test lies on or about the synclinal axis to the north-west of the village, as far as can be judged without an examination of the ground.

Allanmyo Township.—

Of the nine waterless tracts in the Allanmyo township, only two have been considered, as the remainder lie outside the area which has been surveyed on the scale of one-inch-to-one-mile, by the officers of the Geological Survey of India.

Tract No. 1.—Tract No. 1 is a small area containing the single village of Gwegon, population 600, four miles to the north of Allanmyo. It is located near the junction of the alluvial deposits of the Kyeni Chaung with the Irrawadian rocks and Dr. Brown advocates a search for shallow water in the alluvium to the south of the village, rather than by boring in the Irrawadian.

Tract No. 2.—Tract No. 2 includes the villages of Thanat, population 216, Pokolon 315, Yebaw 240 and Sangale 360. All these villages suffer from water shortage in the hot weather, when supplies for human beings are obtained from holes in stream-beds and cattle are driven to the Irrawaddy river some miles away. Thanat, the most northerly village, lies four miles east of Allanmyo. Sangale, at the other end of the tract, is approximately five miles to the south-south-east of Allanmyo. With the exception of Thanat, which lies on Pegu rocks, the other places are all situated on the band of Irrawadian rocks which rises to the east of the narrow belt of alluvium deposited by the Irrawaddy river around Allanmyo and Ywataung.

In Thanat and Pokolon, additional surface supplies from shallow wells may be obtainable. About Sangale, and perhaps between it and Yebok, the question of tapping the "water table" of the Irrawaddy river by means of deep boring arises, but as there is practically no knowledge available as the result of experience on this subject, such borings in these locations could only be regarded as experimental.

Turning now to that portion of the Thayetmyo district which lies west of the Irrawaddy river, waterless tracts occur in the townships of Minhla, Mindon, Thayetmyo and Kama.

Minhla Township.—

Tract No. 1.—Lebingyin, population 148, possesses a tank which dries up in hot seasons, when water is brought from Paikthin in the Minbu district, four miles away. It is situated in the broad expanse of Irrawadian strata which occurs on the western flanks of the Minbu anticline. Possibilities of obtaining suitable underground supplies at reasonable depths in this situation are remote.

Tract No. 2.—Nyaungbingyin, population 220, is said to obtain water from the Irrawaddy, three miles away during the hot weather. This place is presumed to be identical with the Shaukpyingyin on sheet No. 157 of the one-inch map. If this be correct, it lies on rocks of Pegu age which dip to the north-east and possibilities here are not much better than in the previous instance. It is a case where an examination of the ground in detail is necessary before coming to any decision.

Tract No. 3.—Tract No. 3 contains the villages of Kanni, population 400, Kandok 520, Sinmagyat 255 and Didokkan 200. The first three have no wells and in the hot weather water is obtained from tanks up to four miles away. Didokkan alone has a tank and a well, and when these fail, water is obtained from a stream two miles away. Kanni lies at an elevation of 1,004 feet on a ridge which forms the water-parting between two well-marked drainage systems. The local rocks have been mapped as the Tabyin-Laungshe group, which is pre-eminently a shaly and clayey horizon. Dr. Brown considers that there are no prospects of underground water at Kanni.

Kandok is on rocks belonging to the Yaw-Pondaung group with a high dip to the north-east. The geological situation at 1,081 feet on a well defined water-parting is bad. Judging from the map alone Dr. Brown does not recommend boring here.

Sinmagyat is five miles east-south-east of Kandok and is situated on rocks of Pegu age, as is Didokkan, a further five miles away in the same general direction. Both villages lie at approximately 1,000 feet above sea-level near the head of a watershed. A simpler remedy than hazarding boring operations in cases like these would be the construction of tanks to be fed by rain.

Mindon Township.—

The Mindon town-ship contains five waterless tracts :—

Tract No. 1—lying outside the areas which have been geologically surveyed.

Tract No. 2—containing the following villages :—

(1) Kyaukpyok, population 140, with one well which is supplemented by water from the Inma Chaung, two miles away ;

(2) Hmoktalon, population 98, with one well supplemented in the same way ;

(3) Inbyit, population 331, obtaining its water in the dry weather from a stream one mile away ;

(4) Yegyansin, population 45, with one tank supplemented by water from a stream one mile away.

The area enclosing these villages is to be found on sheet No. 115 of the one-inch-to-one-mile survey. It was mapped in 1922-23 by Mr. E. L. G. Clegg and is covered entirely by rocks which he grouped together as the Yaw-Pondaungs, of Upper Eocene age. According to him an alternating sandstone shale facies prevails in the uppermost beds and a sandy one below. The main range of which the area forms part is said to possess a general anticlinal structure but it is complicated by strike faulting. Mr. Clegg stresses the high degree of lateral variation which has taken place in the rocks hereabouts, and in the circumstances it is not possible to generalise on the possibility of obtaining water in these localities. A detailed examination of any proposed site is essential before a definite opinion can be given.

Tract No. 3.—Tract No. 3 lies in an area which has not been geologically surveyed and the same remarks apply to Tract No. 4.

Tract No. 4.—(See preceding sentence.)

Thayetmyo District.—

There are four waterless tracts in the Thayetmyo township. As they are nearly contiguous and all lie on a widespread area of Pegu rocks they are taken together. The affected villages are enumerated below :—

Tract.	Village.	Population.	Remarks.
1	Konniywa	350	No well or tank. Water obtained from wells dug in the stream bed. Supply scanty.
	Kyaukme	200	Ditto. ditto.
	Tayon	150	No well or tank. Water obtained from Inle Chaung one mile away.
2	Pyaukpyu	200	No well. Inadequate tank. Drinking water from a well in the stream bed. Other water from Thazi, 1½ miles away.
	Akyisa	200	No well or tank. Water from the Ponchaung.
3	Okpon	200	No well or tank. Nearest supply at other villages, 2 miles away.
	Sanmagyi	210	No well or tank. Supply from holes dug in the stream bed.

Tract.	Village.	Population.	Remarks.
4	Taungmyit	210	No well or tank. Water from holes in the stream bed. Supply scanty and poor.
	Shanywagyaw . . .	150	No well or tank. Poor drinking water from the bed of the stream. Animals watered at Pani Chaung, 4 miles away.

Tract No. 1 and part of No. 2 lie on the south-west corner of sheet No. 158, and the other two tracts in the western part of sheet No. 159, of the one-inch-to-one-mile survey. The last geologist to report on the area was Mr. E. L. G. Clegg in seasons 1923-24. In sheet No. 158 the two areas concerned lie on the middle sandstone and lower shale divisions of the Pegu group, which are broken up in many places with small faults. Konniywa has an elevation of 421 feet above sea-level but south and east of it is a ridge rising to heights of from 1,300 feet to 1,700 feet. Alternating strata of shales, sandy shales, sandstones and calcareous bands appear to form the ridge. Around Kyaukme is a thick series of shales overlain by sandstone to the west and south-west, which after being folded into a syncline down which the Thazi Chaung flows, rises up to form the outer band of sandstones of the well-known Monatkon dome, lying in the extreme south-western corner of the sheet. The shales in the centre of the Monatkon dome were also found by Mr. Clegg one-and-a-half mile west of Wunledaung, which brings them to about the same distance south of Kyaukme. It is possible, owing to this alteration of sandy and shaly beds, that a favourable site might be found for a deep tube well in the syncline towards the Thazi Chaung, but no guarantee can be given that the water which might be met with would be good, in view of the common occurrence of soluble alkaline salts in the Pegu rocks generally.

The structure near Pyaukpyu is not so satisfactory.

The conditions which bear on this enquiry on sheet No. 159 to the south, are, first of all, the predominantly shaly character of the Pegu beds in the Kadetpyin-Sanmagyi-Myinba valley; these become sandy in the uppermost layers immediately underlying the Irrawadian sandstone to the east, while the high ground around the valley

is formed by intercalations of sandstone. West of this valley is the Okpon dome. The outer band of sandstones on which Okpon itself stands, is overlain by the shales of the Punchaung valley. Neither Okpon nor Sanmagyi are suitably located for deep water tests. The same remarks apply to the villages of Taungmyit and Shanywagyaw which lie on Pegu rocks dipping to the south and close to the overlapping boundary of the Irrawadian.

Kama Township.—

The Kama township, Dr. Brown reports, has three waterless tracts. The first of these lies in a geologically unsurveyed portion on sheet No. 116.

Tract No. 2 is a small area containing only one village, Kywetnwe, with a population of 100 souls. It is 5½ miles west of Kama on sheet No. 160, has neither wells nor tanks and obtains its water supplies from the Made Chaung, one mile away. It is situated on the junction of Pegu rocks with the alluvial deposits of the Made Chaung. If the alluvium be thick enough a shallow tube well might yield a good supply of water, otherwise trials might be made by shallow, hand-dug wells.

Tract No. 3 is a large area stretching along the right bank of the Irrawaddy for approximately eight miles in sheet No. 161. It was geologically surveyed some years ago by Dr. Murray Stuart, whose map shows that it is entirely occupied by Kama clays—a division of the Pegu group. As its name indicates, this series is essentially a clayey one though it does contain sandstone bands in places; the latter are not defined separately on Dr. Stuart's map, nor are dips of the strata recorded. For these reasons it is impossible to come to any definite conclusions regarding the possibility of underground water in the tract. On general grounds Dr. Brown considers it an unpromising one.

The affected villages are listed below:—

Village.	Population.	Remarks.
Onhne	85	No well or tank. Water from the stream. Distance one mile
Dangaing	142	One well at the *pongyi-kyaung*; supplemented by water from the Irrawaddy river. Distance five miles.

Village.	Population.	Remarks.
Thitmozi	125	No well or tank. Water from the Irrawaddy. Distance five miles.
Dagon		
Pyaunggya	135	Ditto. ditto.
Pegya	196	
Leindon	229	
Nyaunggaing	220	
Pebin	54	
Thetkomyaung	200	

Waterless tracts of the Kyaukse district, Burma.

In the Kyaukse district of Burma, nearly the whole of the Myittha Township lying to the west of the Thinbon Chaung and the Samon River, an area of approximately 45 square miles, is classified as a waterless tract. It is found on Survey sheet No. 245 (93 C/7 and C/3) with extensions on to the adjoining sheets to the north and west. For administrative purposes it is divided into the three separate tracts of Hinnyangan, Thittetkon and Yogan.

According to Dr. Coggin Brown's report, the outstanding geological feature of the region is a flat ridge of Upper Tertiary rocks trending from north to south and consisting of conglomerates and gritty sandstones with rare bands of shale. These attain heights of over 600 feet above sea-level and have a high dip to the south-west, two miles west of Gwe.

The possibilities of obtaining good underground water from these Tertiary rocks are remote, but conditions are more favourable on the alluvial areas which surround them and from which they rise; especially is this so in the strip of alluvium forming part of the main Samon belt, on the east of the dry tract.

In the case of the Kyaukse district, unlike others in the "dry zone," the results of an experiment in boring are available. A tube well which was drilled to a depth of 300 feet on a site at Taungdwin, a village on the spread of Upper Tertiary rocks, was a complete failure. When these facts were brought to Dr. Coggin Brown's

attention he suggested another trial at Thittetkon, 3½ miles further east, and within the alluvial area. A successful well was completed here in 1926, which obtains its supply from a bed of coarse sand 75 to 88 feet below surface level.

The Hinnyangan Tract has only one village with 38 households. It lies on alluvium, according to a geological survey by Mr. E. L. G. Clegg (1924-25), and underground supplies should be obtainable, if the alluvial deposits prove thick enough.

The Thittetkon Tract is an important one with 11 villages containing a total of 795 households. The scarcity period when no water exists near the villages lasts from three to four months, when supplies are brought from streams which lie on an average about two miles away. The following villages are within the alluvial area :—Pyawywa, Sizongon, Wettein, Tegyi, Thittetkon and Magyigan. Thittetkon now possesses a supply in its tube well and similar underground conditions probably prevail in the others, with the exception of Pyawywa and Sizongon, where they are not so favourable. The remainder are on the Upper Tertiary beds. The largest village of the group, Gwe, with 268 households, is almost on the edge of the Tertiaries and a promising site for a tube well could doubtless be found east of the village and between it and the Samon River.

Dr. Coggin Brown reports that the Yogan Tract has 9 villages containing a total of 438 households, supplied by distant tanks and water holes for three or four months, in years of drought. Borings are not recommended in the cases of Ywatha West, Yogan, Nyaungwin, Yitkan, Thabyetha and Kyadwin. Reconditioning of old tanks and construction of new ones seem to be the only solution of the problem. Nashayo, Letpanbin and Nyaunggyit are on, or near the Thinbon Chaung, which, however, is not a perennial stream. The prospects of a successful tube well, between Nyaunggyit and Nashayo appear to be fairly good.

Mandalay district: Burma.

There are three waterless tracts in the Mandalay district; two of these lie in the Singu township of the Madaya sub-division and one in the Patheingyi township of the Amarapura sub-division.

Tract No. 1 of the Singu township has an area of about four square miles with five villages, Kadetchin, Yedwet, Pandin, Tayawpingin and Pinle-in, containing a total of 226 households. The village tanks are dry for four months in seasons of poor rainfall, when water has to be carried from streams from ¼ to 1 mile away.

The group of villages is situated on sheet No. 241 of the one-inch-to-one-mile survey, the most northerly being about Latitude 22° 27′ and Longitude 96° 7′. The neighbouring rocks belong to the Mogok gneissose group, which forms an irregular boundary with the alluvium of the Irrawaddy valley. The possibilities of obtaining underground water lie entirely in the alluvium, to the south-west of Kadetchin and to the east of Pinle-in, and if the alluvium is merely a thin skin overlying gneiss, the prospects are poor. If deep alluvial deposits persist up to the gneissic boundary, the prospects are better, but not so good as they are further out into the plain on the west.

The second tract, an area of one or two square miles only, contains one large village, Yenatha, with 250 households. It possesses surface wells and a tank. These are sufficient in years of good rainfall, but in periods of drought, water has to be carried from a stream $4\frac{1}{2}$ miles away.

Yenatha is five miles to the south-east of Pinle-in in Tract No. 1-just described. It lies on alluvium with the nearest gneissic outcrop, two miles to the north. Dr. Brown recommends that the surface wells should be deepened if they have not passed through the alluvium and the outer layer of decomposed gneiss. The possibilities of a tube well supply here depend very largely on the thickness of the alluvium.

The waterless tract of the Patheingyi Township covers an area of four or five square miles and contains nine villages with a total of 410 households. They all possess wells which dry up in the hot season, from mid-February to mid-June, even if the rainfall is fairly good. At such seasons the villages of Yonbin, Kanbyin and Shwepyi obtain water from a well two miles away and the remainder, Bok, Thetkegyin, Mingan, Zidaw, Sinbut and Yontha, from a spring in Bok Hill at a distance of 4 miles. Bok, the centre of this village group, is eight miles north-east of Mandalay. All the villages are built on a narrow alluvial belt between the isolated gneissic hill of Myotheindantaung on the west and the main outcrop of the Plateau Limestone on the east. It is suspected that the alluvial blanket is thin and that it overlies Plateau Limestone, which would account for its inability to hold water for any length of time.

The alluvial deposits of the valley under Mandalay contain water-bearing sands and gravels and while there would be no objection to trial borings west or south-west of the Myotheindantaung

ridge, no guarantee can be given that borings in the area around Bok, would be successful, owing to the probability of the occurrence of Plateau Limestone at shallow depths below it.

Sadon Chaung Irrigation Project, Magwe district; Upper Burma.

At the request of the Public Works Department of the Government of Burma Mr. E. J. Bradshaw was deputed to make a geological examination of the Sadon Chaung Irrigation Project. Preliminary investigations by the Public Works Department showed that the construction of permanent irrigation works on the Sadon Chaung would prove very productive and it was proposed to construct a masonry dam, from thirty to forty feet high, so as to form a tank near the village of Tanaunggwin, which lies on Survey sheet No. 84 P/12 about nine miles north-north-east of the town of Taungdwingyi. The southern part of this sheet, including the reservoir area, was mapped by the late Captain Walker who was killed while working to the west of the area. The mapping of the sheet was completed by Mr. E. L. G. Clegg during the 1925-26 field season and he incorporated Captain Walker's field notes in his progress report for that year.[1]

The beds mapped included Alluvium and rocks of the Irrawadian and Pegu series.

The dam site and the impounding area lie wholly on Irrawadian rocks which were closely examined by Mr. Bradshaw. The Irrawadians lie beneath arenaceous alluvial deposits which are capped by light loamy soil. The alluvium contains a good deal of *kankar* in stringers and nodules and has occasional beds of conglomerate consisting of well-rolled boulders of quartz in a calcareous or ferruginous matrix. The alluvium passes imperceptibly into the upper strata of the Irrawadian series which consists of sandy deposits, false-bedded, ill-consolidated and calcareous in the upper horizons. Thin bands of conglomerate, similar to that found in the alluvium, occur sporadically in the upper beds of the Irrawadian. The chief member of the series is a pale green argillaceous sand mottled brown by iron staining. Though this sandy rock weathers like a shale and puddles when mixed with water, it is not impermeable and was soaked with rain water when seen by Mr. Bradshaw. This rock is but partially consolidated and is very friable. It is

[1] See "General Report for 1926," *Rec. Geol. Surv. Ind.*, Vol. LX, pp. 83-84.

firm when dug into but rapidly disintegrates and crumbles when exposed to air. This green clay sand is said to be underlain by firm brown clay. At the extreme north-eastern tongue of the reservoir area there are exposures of a compact, gritty "pepper-and-salt" sandstone containing small rounded nodules of grey shale and yellow ochre and alternating with beds of shale. These strata are thought to be of Pegu age by Mr. Bradshaw who remarks that it is difficult to trace a precise boundary as the two series merge into one another. All the strata in the impounding area show strong current-bedding but the general dip is steady and to the south-west.

Trial pits had been sunk at the proposed dam site but at the time of Mr. Bradshaw's visit those in the bed of the stream were filled in and the remaining two were obscured by debris which had fallen into them. These pits showed alluvial soil followed by sand and gravel indicating the past or present bed of the stream, while beneath was green clay sand passing downwards into hard brown clay. The strata attest the rapid lateral variation of the rock series.

In discussing the question of the impermeability or otherwise of the rocks of the dam site Mr. Bradshaw remarks that though there was heavy rain at the time of his visit the flows of the trial pits were dry ; he points out, however, that the surface water may have drained out through the debris and through the obviously porous beds which lie above the brown clay. He considers that the soil the sand with gravel, and the clay sand are porous beds and that the clay sand, or mixtures of it with the brown clay, might show but little seepage for a certain period but in the course of time might disintegrate and be a source of leakage which could not be adequately compensated by the sealing effect of the disposition of clay in the interstices.

Firm clay, thanks to its impermeability and high bearing strength, is considered to be a good foundation for earthern dams and, though not ideal, a really hard and homogeneous clay may constitute a reasonably secure foundation for a masonry dam if precautions, such as sheet-piling, are taken to prevent the spreading and welling-up which might occur were it not so confined. Mr. Bradshaw points out that the danger with clay foundations is that the bearing strength may prove insufficient for the concentrated stresses of a masonry dam and that in the case under consideration there is the probability of the existence of lenses of ill-consolidated or permeable materials. The occurrence in rivers of firm hard clay unmixed

with sand is comparatively rare. If sand be mixed with the clay the danger of seepage or undermining from above and of erosion on the down-stream side is greatly increased and it may be doubted whether it would be safe to construct a masonry dam on such foundations. Mr. Bradshaw considers that if construction be decided upon the clay at the dam site should be carefully examined with regard to its thickness, texture and homogeneity and that the site should be more thoroughly proved than has yet been done. In view of the unreliable nature of the rocks themselves, the irregular bedding and the rapid lateral variation, it would be essential to dig a trench at least twenty feet deep on the whole length of the dam site to prove the actual presence of the firm brown clay along the whole line, and by drilling in the trench to ascertain whether there is a sufficient thickness of this rock.

Mr. Bradshaw doubts whether the foundations will prove suitable for a masonry structure but considers that it would be possible to construct an earthern dam which would itself be water-tight and stable. He states that there are, unfortunately, other considerations which are, to his mind, of sufficient weight to give reason for the condemnation of the proposed site of the dam and of the whole impounding area. The coincidence in this area of the Pegu-Irrawadian boundary with that of the Government Reserved Forest is due to the porosity of the Irrawadian rocks and, indeed, the dry zone in Burma owes its aridity to the permeability of the series. Irrigation projects in Irrawadian areas must always be examined with care for it is almost a foregone conclusion that there will be leakage. In successful cases the initial leakage decreases in time owing to the deposition of clay in the voids of the porous sands from the muddy impounded water which percolates through them. The Irrawadian are unreliable rocks and forecasts as to their behaviour are hazardous ; where, as in the present case, there are, besides the porosity of the rocks, other objections to the choice of any particular locality for an impounding scheme, the possibility of success becomes remote.

The nature of the geological structure constitutes the first of these additional objections. Throughout the impounding area the dip is remarkably steady. At the dam site it is down-stream while along the western margin of the impounding area it is outwards. Such a structure would be undesirable in any area in which it was proposed that water should be impounded. In one where the

majority of the rocks are porous it is probable that the amount of the initial leakage down the beds, and so out of the impounding area would be heavy and Mr. Bradshaw doubts whether it would ever be sufficiently reduced by the sealing effect of the clay carried by the percolating waters. He points out that, speaking generally, in the area under consideration the higher the horizon the greater is the porosity of the rocks. The risk of leakage on account of the structure is greatest along the western margin of the impounding area where the dip is outwards and it is there that the youngest beds are exposed. That these rocks are the most porous is a factor which obviously increases the probability of serious leakage and Mr. Bradshaw remarks that a further unfavourable circumstance is that the impounding of water by a relatively high dam would result in the submergence of still higher, and hence more porous. horizons with a correspondingly increased amount of leakage from the higher levels.

Discussing the topography of the proposed impounding area Mr. Bradshaw notes its deceptive nature and how the actual impounding area would be much smaller than what one would expect at first sight. Above the dam site the stream makes a loop which is almost a complete circle. Due east of the proposed site there is a narrow tongue of high ground composed of loosely consolidated arenaceous deposits with high and exceedingly steep cliffs forming the banks of the stream. The breaching of this tongue of high ground by the ordinary processes of mechanical erosion is but a matter of time, and is taking place with unusual rapidity. The main factor is the undermining of the bank due to the erosion of the stream, especially when it is in spate. This source of erosion would be almost entirely eliminated were the flooded stream to gave place to the still waters of a reservoir. Though under-cutting by the stream itself is the chief, it is not the only factor in the piecemeal erosion of the high ground. Heavy rain fell throughout the period of Mr. Bradshaw's visit and though this resulted in there being water in the bed of the stream, the flow was negligible and erosion from that source was *nil*. At least twenty landslips were counted in the banks of the stream and though most of these were small some were of serious dimensions, the largest being either at the dam site itself or on the further side of the tongue of high ground due east of it. It is evident that the ground in the neighbourhood of the dam site is unstable and that this must be the case is apparent when it is remembered that the high

cliffs, which form the bank of the stream and which in some places approach the vertical, are composed of loose sandy deposits. The high ground above the cliffs constitutes a catchment area from which the surface water runs into the stream in numerous streamlets all of which are cutting back rapidly. The lack of cohesion in the rocks together with the steepness of the cliffs greatly increase the amount of erosion effected by rain alone. If two days' rain can produce a large number of landslips it is clear that the amount of erosion during the wet season will be severe and a serious menace to any structure beneath the cliffs. In Mr. Bradshaw's opinion it is doubtful whether it would be possible to construct a dam which would not be outflanked in the course of time. He considers that both from the engineering and the geological points of view the instability of the cliffs and their liability to erosion constitute a danger which should not be underestimated when assessing the possibilities of the success of the project.

With regard to the supply of building materials, materials suitable for the construction of a masonry dam are available in quantity at the site of the dam. The clay sand and its mixture should be avoided and only the firm brown clay used. Building stone suitable for the construction of a masonry dam does not occur in the immediate neighbourhood of the proposed site but some two miles up-stream along the Sadon Chaung and the Thapain Yoh there are large quantities of sandstone boulders of Pegu age. Cart tracks exist and transport should be neither difficult nor expensive. It is doubtful whether it would be possible to find a sufficiency of solid rock with an open face suitable for quarrying, but the sandstone boulders afford an ample supply of suitable stone. At Htonbo, about two miles from Tanaunggwin, there are old lime quarries. These were not examined by Mr. Bradshaw but he understands that the source of the lime is *kankar* and that the quality is not good.

In condemning this site Mr. Bradshaw considers it unlikely that a suitable alternative one will be found within the Irrawadian area and that such a site, if desired, should be sought for up-stream in the Pegu region. Such a course would increase the difficulties of constructing distribution channels but no alternative seems feasible, except, perhaps, the substitution of a weir with direct irrigation from the stream in place of the dam and reservoir of the present project.

Tagundaing Tank Irrigation Project, Meiktila district; Upper Burma.

The Public Works Department of the Government of Burma reported that the present Sinbyugyi Tank near Tezu village, about nineteen miles north of Meiktila town, Upper Burma, which stores up the waters of the Mondetyewin Chaung, had accumulated large quantities of silt and its storage capacity had been considerably reduced. The *bunds* of the Sinbyugyi Tank were being raised two feet but, as the silt deposits continue, it was expected that in the near future the maximum flood level would reach the crest level of the embankment. In preference to undertaking extensive repairs to the Sinbyugyi Tank it was proposed to investigate the possibility of rebuilding the ancient Burmese Tagundaung Tank which is at present in disuse, and Mr. E. J. Bradshaw was deputed to report on the geological aspects of the scheme.

The Tagundaing Tank is supposed to have been constructed during the reign of King Anawrata about three centuries ago. The remains of the old dam are visible in the Mondetyewin Chaung, the feeder of the Sinbyugyi Tank, about two-and-a-half miles south-west of Tezu and take the form of an earthern *bund* about nine hundred feet long and some sixty feet high from the bed of the stream. The Irrigation Engineers consider that this would be the best site for the new dam which would be of masonry or concrete arch type. The catchment area of the Mondetyewin Chaung at the site of the dam is approximately fifty square miles with a probable run-off of about sixty per cent. of the total rainfall. which is about thirty-two inches a year. The available run-off would, therefore, be of the order of 4,460 million cubic feet. Rough figures show that the storage capacity for the proposed tank would be about 428 million cubic feet giving an irrigable area of about five thousand acres, or a net increase of about three thousand acres. Streams in this part of Burma are dry for a considerable part of the year but are liable to sudden and heavy spates, usually in the months of June and August. At the end of October there is again a shortage of water. It is proposed that the surplus water from the Tagundaing Tank should be diverted partly into the Mondetyewin Chaung and so into the Sinbyugyi Tank and on the south side into the Natkan Myaung. The first would have the effect of maintaining Sinbyugyi Tank as a subsidiary tank with greatly reduced and moderated floods, and would considerably reduce the volume of silt deposited

in it. The sluice on the south side, running parallel to the Natkan Myaung, would command an area of about four square miles.

The site of the dam and of the impounding area lies within a region of Pegu rocks, on Survey sheet No. 84 O/16 which was mapped by Mr. E. L. G. Clegg during the 1924-25 field season. To the east of the sheet there is a belt of alluvium on which the village of Tezu is situated. To the west of this, running due north and south, there is a ridge of low hills known as the Taungnyo Hill ranges and composed of rocks of the Pegu series. The strata consist of alternating beds of shale and compact, false-bedded sandstones with occasional thin calcareous bands. The structure is a more or less asymmetric anticline with the axis lying a little to the east of the hill range. Small minor faults are common and it is probable that further to the south a fault forms the broken crest of the anticline.

The site of the proposed dam is a breach in the ridge, which here forms a natural embankment west of which the stream runs till it cuts across it at right-angles at the site of the dam. The average dip of the strata is about 35° to the west, or due up-stream at the site of the dam. On the south side of the breach the dip is steady along the line of the *bund* but swings slightly to the south-west at its southern end, flattening for a short distance. Here, about two hundred yards from the breach, there is a small stream which might be adapted to form an escape channel provided the height were suitable. North of the breach Mr. Bradshaw noticed a certain amount of crumpling, while some of the strata south of the breach show signs of buckling and have evidently been subjected to considerable stresses. Two small faults were noticed south of the breach, one about 100 yards south-east of it and the other near the small stream referred to above. Both these faults appear to be sealed.

At the dam site itself there is exposed a rather coarse-grained, micaceous, "pepper-and-salt," false-bedded sandstone mottled with reddish brown iron-staining. This rock is tough and compact and sufficiently impervious for all practical purposes. Eastwards it becomes rather more argillaceous and friable while the clay partings are more numerous. The sandstone beds average about 18 inches in thickness and have very thin partings of papery shale or very argillaceous sandstone. Occasionally the partings are calcareous. The sandstone and the shale are often ripple-marked and sometimes coated with efflorescent salts. North of the breach the sandstone often contains small nodules of green-grey shale or yellow ochre.

South of the breach the rock is finer in texture and is greenish buff in colour. There are thin partings of very fine-grained, dark shale which also occurs in the rock in the form of small, rounded nodules.

Though the coarse sandstone which occurs at the site of the dam is itself practically impervious, it is freely jointed. The majority of the joint planes are parallel to the bedding planes and so should not greatly affect the tightness of the dam, but those joints which cut across the bedding planes might be a source of leakage at first; the amount would probably diminish in time and the risk is decreased by the fact that in many places the cross-jointing does not intersect the shaly partings at all.

No pits had been dug to prove the strata at the site of the dam nor was any information available as to the extent or shape of the impounding area. In such circumstances it is not possible to give a definite opinion on the suitability of the area for the impounding of water and Mr. Bradshaw considers that his views should be regarded as preliminary rather than final. He states that the sandstone which at the site of the dam is a tough and massive rock may there be considered sufficiently impervious for all practical purposes. The rock sequence itself, consisting, as it does, of an alternation of compact sandstones and thin shale partings, may be pronounced suitable for the retention of water. The geological structure along the line of the *bund* is almost ideal, the strike being parallel to the line of the *bund* and the dip inwards into the reservoir area. For the reasons stated above the impounding area was not examined in detail but the cursory examination made indicated that in all probability it would prove water-tight.

The possibility of the existence of small, concealed faults which might prove a source of leakage is perhaps, not serious since it is to be presumed that the reservoir has been successfully used for the impounding of water in the past. A more serious possibility is that the breach in the ridge through which the stream runs may be due to the presence of a fault plane. The fault, if it exist, is at present concealed by the alluvium but the buckling of the strata in the vicinity of the breach and the existence of the breach itself, make the presence of such a fault a possibility on which no definite opinion can be given until the site is proved by digging. The fact that while solid rock is exposed on the left bank at the breach there is no exposure of any rock other than alluvium for some 100 yards to the south of it, is probably due to the widening of the

breach by erosion of the left bank on account of the right-handed turn made by the stream.

It is recommended that trial pits or, better, a deep trench, should be dug along the line of the proposed dam site to prove the presence or otherwise of continuous solid rock suitable for the foundations of a dam. For the greater part of the length of the proposed *bund* the work would merely consist of the raising of the present level by a few feet. Good alluvial earth is available close to the reservoir area and there is an abundance of good sandstone at the site of the dam itself. The most suitable is, in Mr. Bradshaw's opinion, the tough, compact rock which occurs at the dam site and which should be used in preference to the more argillaceous and friable types which are found east and south of the breach. The sandstone is freely jointed and easy to work.

Mr. Bradshaw suggests that should it be decided to construct an earthern dam it might be advisable to build one with a core wall because of the difficulty of bonding earthwork with the solid rock which occurs north of the breach. He also notes that it is where the present breach in the ridge exists that the embankment will be wholly artificial, and suggests that it might be advisable to cut the escape or overflow channels elsewhere rather than at this point.

Jhansi water-supply United Provinces.

At the close of his field season in Sirohi State, Rajputana, Mr. A. L. Coulson proceeded to Jhansi in order to examine a well concerning which certain questions had been asked by the Garrison Engineer, Jhansi. A newer and a larger scheme for supplying water to the whole of Jhansi Cantonment having been sanctioned meanwhile by the military authorities, the well in question was required to provide only a temporary supply of 80,000 gallons of water daily.

As Jhansi is situated upon a tract of gneissose granite with small stretches of alluvium bordering the rivers, and as this granite is not water-bearing except in the upper decomposed portions, there is no hope of obtaining artesian water by boring in the granites.

On account of the special local conditions prevailing, the area tapped by the well in question may be considered potentially as the elongated mass of alluvium of variable depth and width, stretching upstream from the well. Near the well, there is a natural underground dam of fresh granite and so the feeding effect of the downstream alluvium may be neglected. In order to augment the

supply of water, the well, which is connected to a smaller and deeper well, could be deepened. As an alternative a stone gallery could be constructed from the smaller adjacent well stretching upstream between the larger well, and the fresh granite cropping out on the far side of the Baberi river. This latter method would be less costly but would not have the advantage of increasing the actual storage capacity of the large well by 120,000 gallons (from 160,000 to 280,000 gallons) which would be the result of deepening the larger well by 10 feet, its diameter being 50 feet.

With the oncoming of the hot weather and the continual removal of water from the natural underground reservoir, the water-level drops and, as Mr. Coulson remarks, such a drop might be sufficient to isolate the potential reservoir into a number of smaller disconnected ones. The annual rainfall of Jhansi and its district is about 38·5 inches but, assuming a minimum annual fall of 15 inches and a drainage area affecting the well of 2 square miles, the minimum amount of water falling annually to replenish the reservoir is about 435,000,000 gallons; if but ⅛th of this were available after run-off and evaporation, it would be sufficient to provide 200,000 gallons of water daily provided it were ideally available throughout the whole year. Actually, only 30,000,000 gallons are required annually and in the monsoon the 7,500,000 gallons pumped may be considered as being obtained from the run-off portion of the annual fall, thus leaving but 22,500,000 gallons to be obtained from the natural reservoir during the remaining 9 months. An actual working test alone will tell whether this will be available but, as calculated above, the fall is ample to replenish the reservoir by more than this amount.

A previous test showed 150,000 gallons of water *per diem* in the hot weather but the test was carried out after a heavy thunderstorm and the water was not taken sufficiently far downstream to ensure that it did not percolate back to the well. A new test was to be made and if the supply of 80,000 gallons were maintained, then the probabilities of it being available throughout the whole year would be good at the same time. It must be remembered that such a test does not repeat actual working conditions inasmuch. for the months following the monsoon, the supply has not been drawn upon to the extent of 80,000 gallons daily.

According to Mr. Coulson there are abundant natural subterranean dams throughout the cantonment area along the courses of the Baberi and Dhobi rivers; the latter is better provided with

water-storing alluvium but its drainage area is chiefly the cantonment itself and for reasons of purity of supply, the Baberi river is to be preferred. Should any large supply be required, either a series of wells would have to be sunk or else a supply obtained from a more favourable source without the cantonment limits.

GEOLOGICAL SURVEYS.

Assam.

Whilst examining the sillimanite-corundum deposits in the neighbourhood of Sonar Pahar (near Nongmaweit village), Nongstoin State, Khasi Hills, Assam, Dr. J. A. Dunn made some notes upon the geology of the Khasi Hills plateau. From the Brahmaputra plains southwards the greater part of the plateau is seen to consist of a granitic rock, often gneissic in texture. It varies from a fine-grained rock frequently finely banded, to a coarse porphyritic rock, which also usually shows a certain amount of banding. In colour the rock varies from white to red. So far as could be determined, this granitic rock is intrusive into all the other metamorphic rocks—mainly hornblende-schists and mica-schists—passed over on the march.

In the vicinity of Sona Pahar the dominating metamorphic rock is a sillimanite-cordierite-biotite-quartz-microcline-gneiss with which is interbanded a sillimanite-quartz-schist. An additional rock-type is an orthorhombic pyroxene-diopside-felspar rock. There has apparently been a considerable amount of folding, but the general strike of the rocks is east and west.

The origin of the cordierite-bearing gneiss and the sillimanite-quartz-schist is not clear. There is no doubt, however, according to Dr. Dunn, that they are interbedded and the simplest suggestion would be that they form a succession of highly aluminous sedimentary beds, the sillimanite-quartz-schist representing an extremely pure variety of clay. It is within this aluminous series that the sillimanite-corundum deposits are found.

The bottoms of the wide valleys are usually covered with a thick peat deposit.

Bihar and Orissa. (Bonai and Keonjhar States).

During the field season 1926-27, the Bihar and Orissa party consisted of Mr. H. Cecil Jones (in charge), Dr. M. S. Krishnan and Sub-Assistant L. A. Narayana Iyer.

Mr. Jones continued the systematic geological survey of the iron ore area in the Feudatory States of Bonai and Keonjhar, and worked on the Bihar and Orissa standard sheets Nos. 73 G/1 and G/5. The geology of the area worked over is very similar to that gone over last season. The Iron Ore series occupies most of it. Good sections through the iron ore range are not often seen, but the Samaj stream breaks through the range near Toda (21° 59′ : 85° 11′) and, about 12 miles farther to the south, near Dumaro (21° 50′ : 85° 07′), the Kurhadi stream breaks through, and at each of these points are excellent sections through the range. In the former case, the banded hæmatite quartzite which forms the backbone of the range seems to be very folded and is generally bent into a steep anticlinorium, whilst in the latter case the bedding, which strikes N.N.E.—S.S.W. and dips about 70° to the W.N.W., appears very regular; although folding and faulting are fairly common, these do not seem to affect the general strike and dip of the rocks. In the Kurhadi stream gorge there is a thickness of about 2,500 feet of the banded hæmatite quartzite exposed. At the west end of the gorge the quartzite is overlain by thick flows of basic igneous rock (mainly epidiorite), which in places has penetrated along the bedding planes and cracks in the upper beds of the quartzite, but seems to have had little effect on it. The country at the east end of the gorge is largely covered, and the rocks underlying the quartzite are mainly shales.

An interesting occurrence of volcanic ash, in which are numerous well rounded volcanic bombs, was noted in the above mentioned basic igneous rock. The ash bed is exposed in the Kurhadi stream-course near Dadan Raikela (21° 53′ : 85° 06′) as a fine-grained greenish-grey somewhat schistose-looking rock, in which a number of well rounded and sometimes angular boulders, up to a foot or more in diameter, occur. The rock forming these rounded masses is a rather hard, fine-grained, compact epidiorite, and has quite a different appearance from that of the ash in which it has been embedded. It sometimes contains areas of white quartz which were probably steam holes when the rock was in a molten condition.

The conglomeratic sandstones noted by Mr. Jones last season were found to extend only a very short distance to the south before the granite appeared. The small exposure of these sandstones in the area gone over did not give sufficient evidence to decide their age.

In the extreme south of the area worked, the banded hæmatite quartzite and shales of the Iron Ore series appear to be bent into a north-easterly pitching overfolded synclinorum, the western arm forming the main iron ore range, the rocks of which strike roughly N.-S. or N.N.E.-S.S.W., with a dip of about 70° in a direction W. or W.N.W. The eastern arm strikes roughly N.E.-S.W. with a dip of about 30 to 40° to the N.W. Although there are considerable quantities of good hæmatite in the eastern arm area, the replacement appears to be not nearly as extensive or complete as in the western arm.

Inspections.

Mr. Jones paid two visits to the prospecting work being carried out by the Tata Iron and Steel Co. at their Noamundi iron mines in the Singhbhum district. Mining work has been started on a fairly large scale and the output. when the mine was visited in early April 1927, was about 1,500 tons daily. This mining work has proved that some of the shaly ore can be used in the blast furnaces. This shaly ore is often rather friable and there is a considerable amount of waste of fines during mining, transport, etc. The prospecting work has also shown that the area is very broken up by faults, so that a larger number of prospecting pits and borings would be necessary to obtain anything like a reliable estimate of the quantities of iron ore on the property.

The geological mapping of Keonjhar State, Bihar and Orissa which was commenced in the last field-season, was continued by Dr. M. S. Krishnan during 1926-27. The area mapped lies in Survey sheets 73 F/12, G/5, G/9, G/10 (1 inch=1 mile).

The geological sequence in this part of the country is the same as that given for the adjoining region in the General Report for the last season (*Rec., Geol. Surv. Ind.*, LX., p. 77). The oldest rocks, which are of older Dharwar age, are confined practically to sheet 73 F/12, except for a small area to the west of Kondraposi (21° 48′ 30″; 85° 31′) in sheets 73 G/5 and G/9. A number of irregular inclusions are also found amidst the granites. They consist of hornblende and mica schists, and quartzites; these last show signs of crushing, the fragments having been re-cemented by secondary silica. Microscopically they are seen to consist of quartz grains with sericite as the cementing medium.

Veins of quartz sometimes traverse the planes of schistosity in the schists, and seem to belong to the period of granitic intrusions

since they are free from the effects of pressure prominent in the schists. The usual direction of strike is N.-S., or between this and N.N.W.-S.S.E.; the dip is always high, and frequently vertical.

The Iron Ore series, composed of sandstones, shales, banded hæmatite quartzites, and shales, in ascending order, occupy the whole of sheet 73 G/5 and the adjoining western edge of sheet 73 G/9. The lowermost beds are sandstones, with bands of quartzites and conglomerates. These dip at 15° to 25° in a direction which varies between W.15°N. and W.15°S. The conglomerates contain pebbles of quartz and jasper; the latter are not found as constituents of the older Dharwars in this area, and hence may either have come from a distance, or have been derived from beds which have since disappeared through denudation.

Field evidence shows the existence of two series of shales, one above, and the other below, the banded hæmatite quartzite. Owing to their lithological similarity, distinction between the two shales is difficult. There is probably a slight unconformity between the lower shales and sandstones. The shales strike, on an average, in a N.E.-S.W. direction, the dips being fairly high. The alteration of shales to laterite is a wide-spread phenomenon. At some localities, more favourable conditions have given rise to pockety segregations of iron and manganese ores (limonite, hæmatite, pyrolusite, wad, psilomelane, etc.).

The banded hæmatite quartzites are conformable to the shales. They are composed of alternating bands of hæmatite and quartz, the average thickness of single bands being about 1/10th inch. The rocks are considerably folded with a dip in a N.W. to W.N.W. direction at usually 30° to 60°.

Parts of the area, particularly the hills composed of banded hæmatite quartzite, are capped by iron ore which is a product of metasomatic replacement of quartz layers by the ferric hydrate carried down by percolating waters. The presence of organic acids derived from decaying vegetation and a fluctuating water-table, should have facilitated the replacement. The quartz leached away during the process of replacement is frequently seen at the foot of the hills, or in the immediate neighbourhood.

The granites are intrusive into and younger than the above-mentioned formations, and occupy nearly the whole of sheet 73 G/9, and the part so far mapped in G/10. They generally bear microcline, and are poor in ferro-magnesian minerals. Veins of

quartz and pegmatite seem to be common but Dr. Krishnan has, so far, come across none of the minerals associated with large masses of granite. This points to the complete absence of any mineralising influences.

A granite-porphyry occurs in an exposure near Nardupur (21° 59′ 30″; 85° 33′).

Belonging to the same granitic suite, is a dyke of rather peculiar sub-acid composition, stretching from Sosang (22° 1′; 85° 40′, in sheet F/12), to near Khuntapoda (21° 52′; 85° 36′ 30″, in sheet G/9). The specimens collected from this dyke show types varying from almost pure micro-pegmatite (sp. 36/502; slide 17,468) to augite-diorite with interstitial micro-pegmatite (sp. 36/516; slide 17,480, etc.). Most of these show a fair amount of greenish epidote.

The youngest of the formations are basic igneous rocks, seen mostly as dykes in the granite region and as sills in the Iron Ore series. The majority of the dykes trend conspicuously in a N.30°E.—S.30°W. direction, which corresponds, in some parts at least, to the direction of one set of joints in the granite.

The petrographic types include gabbros, dolerites and basalts; they are devoid of olivine and rhombic pyroxene, but enstatite-augite is sometimes, and interstitial micropegmatite almost always, present. This last characteristic may either be due to the absorption of siliceous material from the granite, or may be a peculiarity of the basic magma itself. There is a great deal of similarity between these and the trap dykes of Cuddapah age in the Madras Presidency, and the dykes in the Bijawars and Gwaliors (*see* Sir T. H. Holland; *Rec., Geol. Surv. Ind.*, XXX., pp. 31-37) which suggests that all these may have a community of origin.

During the field-season, 1926-27, Sub-Assistant L. A. Narayana Iyer was engaged in the geological survey of the Kolhan Government Estate, Bihar and Orissa, on standard sheets 73 F/3, F/7, F/11 and F/16. Sheets F/11 and F/16 have now been comp eted.

Rocks met with included the older metamorphics as inclusions in the Singhbhum granite, the Iron Ore series including the acid and basic volcanic rocks, and the newer dolerite.

The rocks of the Iron Ore series in sheets F/3, F/7 and F/11 are described as consisting mostly of shales, which show little evidence of metamorphism, and in some places even no cleavage, but are massive and earthy. These shales often pass into a white clay or

kaolin, of which some of the hills are made up. In one place this clay was worked for some time for kaolin. The shale is sometimes sandy, sometimes silicified and often passes into the dark carbonaceous shale. There are also thin bands of interbedded sandstones in the shale, and these sometimes form bold ridges. The shale varies from an earthy brown colour to almost a pure white.

The igneous rocks of the area are both acid and basic. In the white shale on some of the hills occurs a gritty rock, which on examination is seen to be either an altered acid volcanic tuff or a sheared quartz porphyry. The latter is a devitrified ancient lava. The ground-fabric of the acid rocks is so similar to the shales, that some at least of the latter may have been derived from these volcanic rocks. Similarly some of the darker shales are derived from the weathering of the dolerites.

In sheet F/7, the basic volcanic flows or sills are found to a greater extent than in sheet F/11. They have been found in the north-east corner of the sheet, in the central portion and west of Sangajata. The first mentioned are in continuation of, and more or less in the same strike with the Saidba volcanic flows mapped by Dr. Dunn in sheets, F/6, F/10 and F/14. A larger development of the basic flow is seen round Kendbai in the Leda Reserved Forest; here the flow consists of numerous bands of dolerite with intervening shale (at times carbonaceous) extending from the neighbourhood of Kendbai W.S.W. towards the Karo River. There are also further bands south of this area running west of the main ridge, Patum Buru, and also thin bands running along it on its eastern flank. Some of these bands west of the main ridge cross the Karo and are found in the hills of the Ambia Reserved Forest. The dolerite in the areas is somewhat altered; the pyroxene has been changed to chlorite, the plagioclase to sericite and saussurite liberating quartz, while the ilmenite has all been changed to leucoxene.

Mr. Iyer puts forward the view that south Singhbhum was an area of volcanic activity as well as north Singhbhum, but that the basic sills and flows do not cover such large areas as in north Singhbhum. An additional interest lies in the presence of acid volcanic rocks in close proximity to basic while the rocks of north Singhbhum show all stages of metamorphism; their supposed equivalents in south Singhbhum have undergone little change.

Whilst investigating deposits of kyanite in this Province, Dr. Dunn made a traverse through Kharsawan and Seraikela States and the Dhalbhum sub-division of the Singhbhum district.

Bihar and Orissa.

During this traverse he noted that the beds in north Singhbhum which he has classified as the equivalents of the Iron Ore series continue south-east into Dhalbhum and carry the same metamorphic facies. From the general east-west strike of the rocks in north Singhbhum there is a gradual swinging of the strike to the south-east so that ultimately in the south-east of the area the strike becomes south-south-east, continuing into Mayurbhanj State.

Dr. Dunn examined the kyanite deposits of Barabhum in the Manbhum district, and is of opinion that the contact between the Chota Nagpur granite-gneiss and the Iron Ore series is not a fault junction, as indicated on the old maps, but a natural intrusive contact. There is, however, apparently an impersistent line of fault some distance to the south of the boundary of the granite-gneiss.

During the field season 1926-27 the Burma Party consisted of Dr. J. Coggin Brown (in charge), Messrs. E. J. Bradshaw, C. T. Barber, P. Leicester, V. P. Sondhi and B. B. Gupta.

Burma Party.

Mr. E. J. Bradshaw resumed the survey of the Sagaing district but contracted malaria and enteric and had to close camp after a week's work on sheet 84 N/16. At the south-eastern margin of the sheet a ridge of Archæan rocks runs due north and south on the right bank of the River Irrawaddy and consists of gneiss with schist and bands of crystalline limestone on its western flank or forming minor hills west of the ridge. The limestone varies from a bluish-grey, laminated rock to a pinkish white marble, usually in thin, discontinuous bands, and is closely folded. The cleavage planes were observed to dip at about 30° towards the east; the bedding is parallel to the foliation planes of the gneiss and usually approaches the vertical, but flattens eastwards to about 45°.

Sagaing district, Upper Burma.

Three miles east of Padu the limestone occurs as bands in a weathered, greenish, biotite schist with the biotite passing into chlorite. The rock in the main ridge is fresher, the predominating types being a pale-grey or white, finely-banded gneiss composed mainly of quartz and felspar with a subsidiary ferro-magnesian

mineral which is usually biotite but sometimes hornblende. White quartz is copiously injected as veins and stringers into all the Archæan rocks. The schist often weathers like a shale, breaking into small iron-stained discs and decomposing into a pale green, calcareous clay.

On the western flanks of the ridge there is a considerable amount of debris which sometimes takes the form of a boulder bed with boulders of quartz or of the various types of gneiss in a matrix of calcareous quartz gravel, the included boulders being angular, sub-angular, or rounded. Eastwards this deposit passes downwards into weathered gneiss *in situ*, and westwards into the quartz gravel which underlies the dark soil-cap of the low ground. This quartz gravel is similar to the matrix of the boulder bed and consists of a calcareous grit or gravel with small, usually unrounded, pebbles and boulders of quartz, gneiss or limestone. Though false-bedding was noticed in places the rock is more or less incoherent. The general dip is uncertain but is probably low and towards the W.N.W. The size of the pebbles increases steadily as the ridge is approached until the deposit merges into the low scree of debris from the ridge. The determination of the age of this deposit requires further field work. Though no fossil wood was noticed and though the deposit has clearly been derived locally rather than transported, it will probably prove to be Plateau Gravel rather than Older Alluvium.

In the hills between Saye and Ondaw the calcareous quartz sand or gravel is underlain by a Tertiary series of thin beds of sandstone with intercalated, crumbling, calcareous shales in beds a few inches thick. The sandstone is usually fawn in colour, and friable. It is sometimes compact, ferruginous, and laminated, sometimes incoherent and coated with efflorescent salts. Springs are common but the water is usually saline. The hills are low and undulating with the dip and strike of the rocks very variable. A small fault was noticed on the road from Saye to Yemyet. As no fossils of any kind were found, further field work will be necessary before it will be possible to subdivide these Tertiary rocks into Pegus and Irrawadians.

Amherst district, Burma.

Before his deputation to the Toungoo and Salween districts Mr. P. Leicester worked in the Amherst district for a short time and mapped part of sheets 95 E/10 and E/13 and completed sheet E/9.

The granite, which occurs along the coast in sheets 94 H/12 and 95 E/9, is continued southwards into sheet 95 E/10, forming the low hills of Takalwin Taung (97° 42′ 40″; 15° 45′ 0″) and Thabut Taung (97° 42′ 45″; 15° 42′ 0″) situated to the west of Tinyu.

Both Thabut Taung and Takalwin Taung are composed of biotite-granite. Takalwin Taung slopes steeply to the sea on the west and on the sea shore there are excellent exposures of distinctly banded biotite-granite, with xenoliths of dark hornblende granulite like that found at Amherst and in the other granite occurrences along the coast in sheet 95 E/9. The xenoliths, some of which are considerably twisted, are drawn out in a direction N. 45° W. Both the granite and the xenoliths are cut by later veins of porphyritic granite.

Thabut Taung is separated from the sea by a narrow band of alluvium and a sandy shore. The granite, a biotite-granite, exhibits remarkably good jointing resulting in the formation of tabular blocks and the ground around the hill is strewn with granite boulders. The eastern slopes of both hills are covered with laterite near the foot and beyond the edge of the laterite is a fertile band of alluvium, a continuation of the alluvium found to the north, stretching to the railway on the east.

The westerly dipping sandstones and shales of the hills on the coast near Amherst appear to be represented by the sedimentary rocks which form Mawpalaw Taung (sheet 95 E/13. 97° 46′; 15° 52′). This hill is situated east of Karopi and forms a short ridge, with a direction N.N.W.—S.S.E., around which tin mining is being carried on on a small scale. The hill is composed of red, buff and white sandstone and banded quartzite associated with shales and dark micaceous slate. The whole is cut by quartz veins and stringers which presumably carried the tin found in the laterite at the foot of the hill. The strike of the sandstones is N. 25° W., with a dip of 45° to the west.

The tin ore which is recovered from the laterite at the foot of Mawpalaw Taung by sluicing during the rains and by panning, is grey cassiterite with a little black cassiterite. The ore appears to be derived from small cassiterite-bearing quartz stringers intruded into the sandstones during the period of granitic intrusion of the province. The tin has been concentrated in the alluvium of the hill-sides and now appears scattered through the laterite deposits in the vicinity.

Mr. P. Leicester, in the course of the work of the Rangoon Water-Supply and Hydro-Electric Survey Party, mapped parts of sheets 94 B/16, 94 F/3 and 94 F/4 in the Toungoo and Salween districts. The geology of this area has already been referred to under the Rangoon Hydro-Electric and Water-Supply Survey on page 29.

Toungoo and Salween districts, Burma.

The fine-grained granite, mentioned on page 31, when examined under the microscope. proved to be a soda-granite with quartz, dominant idiomorphic albite and subsidiary allotriomorphic orthoclase and large well preserved laths of brown biotite.

The medium-grained granite shows quartz with dominant orthoclase, perthite, albite, biotite and accessory magnetite, and is thus a potash granite. Among the granites met was adamellite consisting of quartz, orthoclase and labradorite in nearly equal proportions with biotite and accessory magnetite : boulders of hornblende-biotite granite are of frequent occurrence in the stream-courses.

About three miles S.E. by S. of Pyagawpu village an interesting example of river capture was noticed. The Bilin Chaung has captured the head waters of a stream flowing northwards into the Thelaw Klo and has since continued to cut its way downwards through the alluvium and the underlying slates until. at the bend where the Bilin Chaung turns to flow south-eastwards. it is now 75 feet below the valley of the former stream, leaving a cliff of alluvium at the southern termination of the Pyagawpu valley.

Lower Chindwin district, Burma.

Mr. V. P. Sondhi mapped parts of sheets 84 J/16, J/15, J/14, N/4 and N/3, in the Lower Chindwin district, Upper Burma and recognised the following series and rock types :—

Alluvium,
Plateau Gravel and Plateau Red Earth,
Irrawadian series,
Pegu series,
Igneous rocks.

The area examined forms the catchment area of the River Chindwin, which is flanked on both sides by belts of alluvium of variable depth and width, generally consisting of a buff to brown sandy clay, resembling weathered Irrawadian sand-rock, from which

most of it is doubtless derived, though locally its lithological characters are highly variable. In the vicinity of the volcanic tuff deposits it is seen to be intimately mixed with the latter and along the river banks near Monywa (22° 7′; 95° 8′) it is frequently found to contain discontinuous bands of ferruginous conglomerate, with occasional pieces of rolled fossil wood.

Most of the country north of the North Yama Chaung, which has an easterly course in Sheets 84 J/16 and 84 N/4, is occupied by the Irrawadian series, often covered by patches of alluvial mantle consisting of an unstratified deposit of incoherent yellowish sand, sometimes stained red with iron oxide. For the most part it is pure, though varieties mixed with clay, or locally containing lenses of pure tenacious clay, are not uncommon. Discontinuous bands of hard ferruginous conglomerate and grit were noticed at several places in this deposit and locally it is found to be very rich in silicified tree trunks, which are sometimes very large. Along the River Chindwin the sand is generally hardened into a loose sandstone and often shows false-bedding.

The outcrops of the Irrawadian series are usually capped by a surface deposit of Plateau Red Earth, consisting of a brick-red sandy clay or of Plateau Gravel; the latter is the more frequent of the two, consisting of large rounded quartz pebbles with fragments of fossil wood and ferruginous concretions in a loose, reddish, gritty matrix. West of Kani (22° 27′; 94° 51′) it contains an abundance of fossil tree trunks and near Natyin Daung (22° 31′; 94° 57′) it is particularly rich in ferruginous concretions.

South of North Yama Chaung a portion of the Pegu series was examined while its junction with the alluvium was being mapped west of Monywa. The lithology of the series differs widely from the type sections in the oil fields, the rock being a bedded calcareous sandstone. The dips are very variable and cannot be relied on, on account of the great disturbance caused by igneous activity in the late Tertiary period manifest in a number of small exposures in the area.

The chief geological interest in the area centres round the varied suite of intrusive and extrusive igneous rocks, a more or less continuous line of which runs towards the north and has been followed for about 25 miles. For the last 13 miles or so they take a north-easterly direction and form a chain of extinct explosion craters which constitute a remarkable topographical feature of the country.

The igneous occurrences, which are manifested in a variety of forms, may be grouped with regard to their geographical distribution, as follows:—

1. Rhyolitic extrusion, with associated rocks, west of Monywa.
2. Songyaung explosion crater.
3. Myayeik Taung occurrences.
4. Silaung Taung basaltic mass.
5. Okkan upland extrusive and intrusive rocks.
6. Explosion craters from Leshe (22° 16′; 94° 57′) to Okaing (22° 24′; 95° 3′).
7. Natyindaung basaltic mass.
8. Isolated tuff deposits.

About seven miles W.N.W. of Monywa, in Sheet 84 N/4, a couple of hump-shaped hills stand conspicuously above the surrounding plain north of the Ywashe-Yinmabin road. They are composed of highly weathered rhyolitic tuff and agglomerate with occasional blocks of rhyolite, and seem to have undergone hydrothermal alterations resulting in the introduction of copper ore, which was changed later into malachite and chalchanthite, occurring as veins and impregnations in the tuff and sometimes containing disseminated grains of pyrite.

The low ground between the two hills is occupied by a highly decomposed mica-hornblende-porphyry, traversed by veins of calcite; at the northern end of Hill "994" there occurs a pink quartz porphyry in the form of a dike partly running into the North Yama Chaung.

Half-a-mile north of Mogyobinkanbya (22° 3′; 96° 3′) a highly denuded conical hill of rhyolitic tuff and breccia is described by Mr. Sondhi as cutting through the Pegu sandstone, and another of rhyolitic tuff and agglomerate cuts through the sandstone of the same series two miles E.S.E. of the village.

Two miles east of Songyaung (22° 13′; 95° 3′) on the right bank of the River Chindwin, opposite Alon, is a low N.E.-S.W. hill with a gentle slope on all sides except the north where it ends abruptly over a shallow lake, with a scarp about 100 feet in height, deeply truncated near the north-eastern end and marking the site of an extinct crater. That part of the hill which abuts on the river is composed of a highly jointed, comparatively fresh, dark, olivine basalt, which under the microscope is seen to contain well-developed olivine phenocrysts in a ground-mass consisting of felspar laths,

minute grains of olivine and augite, and magnetite dust. A little away from the river the rock becomes highly scoriaceous and vesicular. Further west it is replaced by a very characteristic bed about 6 feet thick, of lapilli held together by a sparse amount of an easily weatherable cement composed of volcanic ash. South-west of the lapilli bed there is a deposit of pyroclastic material, consisting of a number of unconsolidated beds of basaltic tuff, with a quantity (which varies in different beds) of rounded quartz pebbles, sand and occasional pieces of fossil wood. At different horizons in this deposit there occur beds of fine volcanic dust and ash, which are often finely laminated. Repetition of the beds of coarser pyroclastic material and laminated volcanic dust marks the different phases of the explosive energy of the crater, and suggest that the material was deposited by a series of rapid explosions of varying intensity and short duration.

The bulk of the deposit is composed of tuff with small basalt fragments, the general paucity of large blocks being very conspicuous. It is greenish brown when fresh but becomes darker on the weathered surface. The general dip of the deposit is to the south but near the centre of activity it is variable in direction as well as in degree. Some natural caves between the bedding planes, and a few small faults were observed, the latter being probably caused by subsidence of the cave-roofs.

One mile west of Myayeik (22° 8′; 95° 1′) is a group of three small elevations known as Myayeik Taung. The main hill is composed of silicified rhyolite with blocks of quartzite on its northern side. The small hill to the west is of shattered quartzite and highly altered basalt, and in the Yamadaw Chaung in the south-west there is exposed a white rock composed of decomposed felspar in which crystals of biotite are very prominent. One mile W.S.W. of this, quartzite and basalt are again exposed in a section along the North Yama Chaung.

East of Myayeik there is another small hill of purple quartz porphyry with specks of white decomposed felspar and hexagonal plates of glistening biotite.

About one mile north of Silaung (22° 10′; 94° 59′), Mr. Sondhi reports, is a plateau-like elevation about 1¼ miles long and ¾ mile wide. It is composed of a dark-grey olivine basalt similar to that of Songyaung crater, but unaccompanied by lapilli or tuff. On the other hand pink calcareous sinter with embedded fragments of basalt,

is met with some way down the slope of the hill. It is surrounded on all sides by the alluvial plain, except to the north-west where it appears to cut through yellowish sand with fragments of grit, apparently belonging to the Irrawadian series. On the west and south-west a slightly metamorphosed granite, much decomposed at the surface, is met with in a small stream.

One mile west of Silaung Taung another broad plateau-like elevation is covered by an old green basalt, interbedded at places with quartzite. The basalt is highly decomposed. but the chief interest of the exposure lies in the occurrence in it of a variety of intrusive rocks. Near Okkan (22° 11′; 94° 57′) a coarse-grained white granite, composed of an equal amount of quartz and felspar with a little hornblende, is found weathering into a crumbling white earth.

One mile east of Taungbu (22° 12′; 94° 57′) is an occurrence of granophyre, a very compact rock, grey in colour, with white crystals of felspar and shining quartz. Under the microscope an interesting gradation from the cryptocrystalline to a perfect spherulitic texture is noticeable. The interspaces between the spherulites are occupied by a crypto granular mixture of quartz and felspar, passing into a cryptographic texture on the margins of the spherulites which in turn passes to a true spherulitic texture towards the centre. The spherulitic texture is sometimes seen developing round the quartz and felspar phenocrysts. Other varieties of granophyre were met with in small streams north of Taungbu.

South of Chindaung (22° 14′; 94° 57′) the hill marked Myetthaung Daung on the map is composed of a vesicular, dark olivine basalt with phenocrysts of olivine, augite, hornblende and plagioclase, embedded in a ground-mass of the same minerals with abundant laths of felspar and a little glass occurring interstitially. It appears to rest upon the quartzite.

At Chindaung there is another hillock of a fresh, highly vesicular, olivine basalt very much finer grained than that described above.

Half-a-mile west of Chindaung a granite boss is exposed in a roughly circular outcrop of about 1½ miles diameter. It is very coarse grained, white in colour, and speckled with glistening biotite. On the west it lies in contact with quartzose grit and sandstone, presumably of the Irrawadian series, which appears to be hydrothermally affected. On the north it is overlain by a surface deposit of Plateau Gravel.

Mr. R. D. Oldham late of this Department wrote a detailed description of the geology of the explosion craters from Leshe to Twindaung,[1] to which there is little to add. The following remarks may be considered a summary of Mr. Oldham's observations, together with such additional information as came to Mr. Sondhi's notice.

A string of explosion craters, about eight in number, occurring in the form of circular pits from half-a-mile to 1¼ miles in diameter and 150 feet in depth, runs from Leshe in a north-easterly direction for about 13 miles, crossing the River Chindwin at Shwezaye (22° 21′; 95° 0′) and ending at Okaing (22° 24′; 95° 3′). The pits to the west of the river Chindwin, *i.e.*, at Leshe, Twinywa and Taungbyauk, are steeply walled by a deposit of bedded basaltic ash and tuff, about 50 feet thick and resting upon the yellowish brown sand of the Irrawadian series. The outer slopes are very gentle and are covered by the volcanic deposit for one to three miles from the crest of the crater pit. Near the margins of the deposit the latter is invariably seen to overlie the Plateau Gravel. In three of the craters, one at each of the above-named villages, the floor is partially covered by lakes, which being below the level of permanent saturation are fed by small springs oozing out near the edges.

The absence of any hard rim of basalt in these craters, saving a narrow basalt plug in the Taungbyauk crater, is very conspicuous, and it seems highly probable that the pits were originally much narrower and deeper, and that the present width and comparative shallowness are due to the gradual infilling of the pit by material washed down from the receding sides, which stand unprotected in the absence of a hard crater rim.

The Twindaung crater on the east bank of the River Chindwin differs from the rest in having a partial rim of basalt on its three sides and, on that account, of all the craters it is the deepest and the most perfectly preserved. It further differs in the nature of its ejectamenta which include, apart from the usual variety of olivine basalt met with at other places, blocks of hornblende andesite, peridotite and augite rock.

The Natyin Daung basalt mass (22° 30′; 94° 59′) occurs in the form of a double cone cutting through the Irrawadian sand, and is composed of a characteristic light grey to dark grey olivine basalt.

[1] *Rec. Geol. Surv. Ind.*, Vol. XXXIV, pp. 137—147.

The two cones are separated by a narrow depression, the floor of which is level with the surrounding plain. The southern hill, which is the smaller of the two, presents a dyke-like appearance as viewed from the south, and shows deep vertical joints, whereas on the northern slope regular horizontal joints are developed, giving the rock a perfectly bedded or platy appearance. On the northern hill the basalt is darker in colour and much scoriated.

Denuded remnants of older volcanic tuff deposits of a basaltic nature, which, judging from the distance from the craters at which they are met, must have been more extensive than the newer ones, are encountered at several places south of the Twindaung crater and at Bambwe (22° 13′; 95° 0′). Their general outward appearance and curvature suggest that the craters from which they originated occupied very much the same position as do the existing ones.

On the east bank of the river Chindwin, opposite Natlabo North (22° 18′; 95° 2′), a cliff of basaltic tuff, similar to that of the other craters, stands conspicuously over the river, accompanied by huge blocks of basalt. The latter suggest the proximity of the source, but no crater was actually found in the vicinity.

It may be noted that in the area under consideration more than one period of igneous activity is noticeable, and that the youngest approximately coincided with the older in geographical position. The older, or late Tertiary, activity is represented by a more or less complete cycle as under:—

(1) The extrusive phase—including the isolated basaltic tuff deposits at Bambwe and south of Twindaung, the older basalt of the Okkan upland and the rhyolitic extrusions west of Monywa.

(2) The plutonic phase—including the granites of the Okkan upland and west of Silaung Taung.

(3) The dyke phase—including the granophyres of the Okkan upland, the quartz porphyry and mica-hornblende-porphyry east and south of Myayeik.

The most recent volcanic activity is manifested by the extrusive phase only, and is represented by the existing crater pits and their ejectamenta, including the Natlabo tuff deposits which rest upon the Pleistocene Plateau Gravel.

The olivine basalt masses which cut through the Irrawadian sand-rock, and the older basalt at Silaung Taung, Myetthaung Daung,

Chindaung, and Natyindaung, are comparatively fresh and undecomposed, and are much younger than the green basalt of the Okkan upland, but there is no evidence to show how far these basaltic extrusions are connected with the latest or post-Pleistocene period of igneous activity.

After short instructional visits to Yenangyaung and Singu where he studied the Tertiary type sections, Sub-Assistant B. B. Gupta resumed survey work in the Lower Chindwin district, completed sheets 84 J/15 and J/16 and mapped part of sheets 84 J/11 and J/12.

The greater part of sheets 84 J/15 and J/16 is occupied by rocks of the Irrawadian series. In the northern part of sheet 84 J/15 there is an inlier of the Pondaung stage and in sheet 84 J/16 there are some igneous outcrops. The rest is covered by Recent deposits. Loose sandstone, grits and ferruginous conglomerate are the chief components of the Irrawadian, though subsidiary beds of shale are not infrequently found. Indurated sandstone was noticed in the river bed near the village of Thanlegyi (22° 12′; 94° 54′, approx.) and also in a *nala* about half-a-mile south of the village. Wazin Taung is composed of Irrawadian rocks, some of the lower beds being metamorphosed as a result of igneous intrusions in the area. A vertebrate fossil, provisionally preferred to *Mastodon*, was found about three-and-a-half miles E. 10° N. of Nyaunggaing (22° 12′; 94° 47′ 30″, approx.). Fossil wood is plentiful throughout the area covered by the two sheets.

The Pondaungs are represented in sheet 84 J/15 by sandstones and conglomerates of the usual type, no fossils being found in them. On the western boundary the Irrawadian appears to rest unconformably on the Pondaung. In sheet 84 J/16 basalt and olivine basalt tuffs were noticed about a mile south of Obo (22° 10′; 94° 54′ 30″, approx.), the chief component of the tuff being olivine basalt. The cementing material is calcareous and quartz was noticed under the microscope. Basalt was also found in the pass between the two conical hills south of Wazin Taung. Decomposed biotite granite was noticed north-east and south-west of Wazin Taung and a very small outcrop of dolerite was seen cutting through the granite exposed north-east of Wazin Taung.

The rock formations met with in sheet 84 J/11 are Irrawadian, Pegu, Yaw Shales and the Pondaung Stage. The last three have

a general westerly dip and crop out consecutively, a scarp forming the eastern boundary of the Pegus. The Irrawadians are faulted against the Pondaungs by a strike fault which runs approximately north and south. The Pegus are chiefly composed of massive muddy sandstone with intermediate thin bands of rather arenaceous shale. Because of insufficient fossil evidence they have not been differentiated. Current-bedding was noticed in the sandstone in some of the sections. A narrow outcrop of Yaws, about half-a-mile wide, was mapped; the rocks are chiefly unfossiliferous shales. Sandstone and conglomerates predominate in the Pondaungs. The constituent pebbles of the conglomerates are rather smaller than those seen in the inlier noted above or those noticed in the Myaing area. The general tinge of the sandstones is greenish, while a reddish earth results from the decomposition of the argillaceous beds. No fossils were found in these rocks.

The area west of longitude 94° 35′ on sheet 84 J/12 was surveyed by the late Captain F. W. Walker during the 1922-23 field season (*Rec., Geol. Surv. Ind.*, Vol. LVI, p. 41). Of the remaining portion the north-eastern corner was mapped by Mr. B. B. Gupta during the period under report. Pondaungs and Irrawadians were the only formations mapped. The fault between the Pondaung stage and the Irrawadian, noticed in sheet 84 J/11, was traced as far south as the Tinzon Chaung, west of Kabyu (22° 12′ 30″; 94° 40′). A vertebrate fossil referred to *Stegodon* was found south of Kabaing (22° 12′ 30″; 94° 41′, approx.).

Resident Geologist, Yenangyaung Oilfield.

At the request of the Government of Burma, the former practice of having an officer of the Department stationed permanently at Yenangyaung has been revived. Throughout the year under report Mr. C. T. Barber acted as Resident Government Geologist, Yenangyaung, and as Official Member of the Yenangyaung Advisory Board.

In addition to his advisory duties Mr. Barber submitted several confidential reports on various subjects.

Central Provinces and Central India.

During the field season of 1926-27 Mr. Tipper took over temporary charge of the Central Provinces and Central India Party while Dr. Fermor was in charge of the Office.

Chhindwara district.

Mr. Crookshank continued his mapping in the northern Satpura tract, the ground surveyed including portions of sheets 55 J/10 and J/14, and lying mainly in the northern part of the Chhindwara district, but partly in the southern part of the Narsinghpur district. The ground surveyed was occupied entirely by Gondwanas and Deccan Trap, in the proportion roughly of 3 : 1.

The Gondwanas are referred by Mr. Crookshank wholly to the Mahadeva division, and the observed thickness in the scarps east of the Dudhi river is some 1,600 feet. These strata can be divided into two fairly well defined sub-divisions, of which the upper lies to the east and consists of about 300 feet of fine-grained sandstone with carbonaceous clays and a little conglomerate. In these strata fossil-plants are abundant, and some dozen different species were collected; the specimens have been forwarded to Professor Sahni for identification.

The lower sub-division is best seen to the north and west, and is characterised by masses of coarse conglomerate and numerous variegated clays. Normally it is unfossiliferous, but unidentifiable plant remains are fairly common in the silicified clays, which occur wherever Deccan Trap intrusives pierce this series.

The junction between these two sub-divisions is well marked on the northern edge of sheet 55 J/14. Especially is this so near Saonri, where the plane of contact is clearly an unconformity. Passing from east to west, there is no sign of any boundary. Indeed, the red clays of the lower sub-division are in places found intercalated between carbonaceous clays typical of the upper sub-division.

The Mahadevas lie almost horizontal, and such dips as have been observed are due to the disturbing effect of the Deccan Trap intrusions rather than to any regional folding. Minor faults appear to be common, and are frequently seen in places where carbonaceous beds exist and make observation easy, but no faults of importance were definitely fixed.

The Deccan Trap rocks occupy in all about one quarter of the area mapped and frequently form important hill ranges. They consist mainly of immense doleritic sheets several hundred feet thick. Dykes are also fairly common, but are much less conspicuous. In many cases they merge into the sheets. Although the tract mapped lies to the north of the country occupied by surface lava flows, Mr. Crookshank believes that two hills lying north of Kotri

may contain the remains of a true flow, although this is by no means certain. The petrology of this interesting set of intrusives is similar to that of the country noticed in the previous General Report.

Nagpur district.

During the season 1926-27, Mr. W. D. West spent four months on the continuation of his survey of the Deolapar sheet (55 O/6) of the Nagpur district, working to the north of country previously mapped, especially in the neighbourhood of Silari, Khapa, Kadbikhera, Tuyapar, Pindkapar and Karwahi. The last named village lies near the Seoni border, where Mr. West succeeded in joining up his work with ground mapped by the late Mr. Burton in 1912-13.

The general result of this season's work is to confirm the succession of strata as previously deduced and to render possible a general view of the disposition of folds throughout the southern portion of this sheet. In a generalised map it is shown that the important Silari-Salai anticlinorium of calc-granulites and calcitic marbles of the Utekata and Lohangi stages runs right across the map in an E.S.E.—W.N.W. direction. To the north of this is the Dongartal-Pindkapar synclinorium of dolomitic marbles of the Bichua stage, with an associated anticline (the Tuyapar anticlinorium) of the Chorbaoli quartzite stage, with a core of calcitic marbles and calc-granulites. Further to the north between Pindkapar and Karwahi is a belt of folded dolomitic marbles and quartzites of the Bichua and Chorbaoli stages respectively, in which the marbles occupy broad synclines and the quartzites narrow separating anticlines. To the south-west of the Silari-Salai anticlinorium is the broad Junewani syncline of dolomitic marbles. Between the Chorbaoli and Lohangi stages comes the Mansar stage or manganese-horizon, when present. From the distribution of manganese ore to the south, north and east of the Junewani syncline, and of the quartzites of the Chorbaoli stage, including the absence of the Chorbaoli stage in the belt between the Silari-Salai anticlinorium and the Junewani syncline, Mr. West deduces the existence along the northern edge of the Junewani syncline of a thrust-fault with an E.S.E.—W.N.W. strike. This deduction is perhaps confirmed by the existence of a band of fault breccia on the southern edge of the sheet some three miles E.S.E. of Pauni. A newly discovered deposit of manganese ore northwards of Deolapar and between milestones 44 and 45 on the Nagpur road falls into the correct place in

the stratigraphical sequence on the interpretation given. A general E.S.E.—W.N.W. strike of the folds has been previously noted. Towards the east side of the sheet, however, the axes of the folds are curling round to an E.N.E. direction in conformity with the general strike of the gneisses and schists to the east. The mapping indicates a gentle pitch in the folds, the direction of which is not, however, uniform throughout the country mapped. Thus the Dongartal-Pindkapar synclinorium is closed at both ends, indicating an E.S.E. pitch at the western end and a S.W. pitch at the eastern end. A study of Mr. West's map indicates that in addition to the thrust-fault already mentioned there may be at least one other parallel thrust, namely, south-west of Jhanjharia, where the dolomitic marbles of the Dongartal-Pindkapar synclinorium approach so close to the calcitic marbles of the Silari-Salai anticlinorium that a portion of the intervening strata may have been cut out by a thrust.

On the petrographical side various points may be noticed. In the Dongartal-Pindkapar belt of the Bichua stage, which, broadly speaking, consists of dolomitic marbles, many interesting mineral assemblages are found. These include anthophyllite-schists, anthophyllite-spinel-chlorite-schists, grossularite-diopside-microcline-granulites and wollastonite-grossular-vesuvianite-diopside-granulites. Wollastonite does not appear to have been recorded before from the Sausar series, while the grossularite-vesuvianite assemblage appears not to be common in regional metamorphism.

The rocks of the Chorbaoli stage in the country between Pindkapar and Karwahi include not only muscovite-quartz-schists but also glassy quartzites often carrying microcline, the two rocks replacing one another laterally along the strike and also across the strike. It is not known whether these changes are due to original differences of composition or to different response to metamorphic forces in accordance with which microcline has in places been converted by pressure into muscovite.

Concerning the origin of the calc-granulites (Utekata stage) Mr. West has an important suggestion to offer. These calc-granulites are usually regularly banded with layers that are alternately characterised by labradorite and microcline felspar. Dr. Fermor and the late Mr. Burton have interpreted these rocks as due to the *lit-par-lit* injection of calcareous sediments by an acid igneous intrusive, the labradoritic layers representing the original sedimentary

bands and the microclinic layers the intrusive bands. Mr. West has hitherto accepted this explanation, but now suggests the possibility that the banding is due to some kind of seasonal variation during sedimentation. In the centre of the Silari-Salai synclinorium are magnetite-biotite-gneisses similar to those that have been regarded in the Sausar tract as representing the igneous rock that was responsible for the formation of the calc-granulites by *lit-par-lit* intrusion. In the calc-granulites adjacent to his magnetite-biotite-gneisses Mr. West has found similar magnetite granules in both the labradoritic and microclinic layers, and he considers that this shows that the calc-granulites and the magnetite-gneisses are closely related; the evidence rather suggests that this close relationship is due to the rocks being part of a sedimentary succession, which varies from a gneiss at the bottom to calcitic marbles at the top, with banded calc-granulites as an intermediate variety.

Nagpur and Bhandara districts; Central Provinces.

For several years Sub-Assistant D. S. Bhattacharjee has been engaged in surveying portions of the Nagpur district situated upon the Ramtek belt of country occupied by the Sausar type of schists, which lie exclusively to the north of the main line of the Bengal-Nagpur Railway. Towards the end of the previous field season, Mr. Bhattacharjee commenced work on the Maunda sheet (55 O/8) surveying the north-west corner. During the present season he has completed this sheet and also surveyed a portion of the western margin of the Bhandara sheet (55 O/12). Practically the whole of this tract lies to the south of the Bengal-Nagpur Railway line and is occupied, where not obscured by alluvium, almost exclusively by Archæan rocks, of which the metamorphic schists belong to a somewhat different type from those of the Sausar belt. In grade of metamorphism they are comparable with portions of the Chilpi Ghat series with which they are probably in stratigraphical continuity. They have been previously treated by Mr. P. N. Datta, who made some years ago a general survey of this part of the Central Provinces, as belonging to the Dharwars, and it will be convenient to continue to refer to the phyllites and schists of this belt as Dharwars until their exact relationship to the Chilpis and to the Sausar series has been proved. Although the country is largely covered by alluvium there are numerous exposures to be found in stream-beds and also a certain number of small hill ranges in which the rocks are

exposed. The general strike of this belt, which may be referred to as the Bhandara belt of the Dharwars, is E.N.E.—W.S.W., parallel to the strike of the Ramtek belt of the Sausar series to the north; it is anticipated that a careful examination of the border country between the two belts may lead to an elucidation of their relationships. Excluding a small area of Deccan Trap with underlying Lametas encroaching upon the south-western margin of the Maunda sheet, the whole of the country surveyed consists of Archæan rocks with overlying alluvium. The Archæan rocks have been subdivided by Mr. Bhattacharjee into the following lithological groups :—

(1) Amphibolite,
(2) Chilpi Ghat series (Dharwars), classified provisionally into five types of zones—(*a*) felspathic muscovite-quartz-schists with tourmaline and lenticles of vein quartz carrying wolfram, (*b*) quartzites, phyllites and slates, of which the argillaceous rocks contain a few knots of sericite and crystals of magnetite and garnet, (*c*) highly ferruginous quartzite zone; (*d*) coarsely knotted sericitic zone, and (*e*) coarsely quartzitic zone.
(3) Amphibole-schists in which the amphibole is often actinolite.
(4) Crystalline series consisting of gneisses, granite, pegmatites, vein quartz and muscovite-schist.

It has not yet been possible, on account of the detached nature of the occurrences, to decipher the sequence of rocks in this tract, but it is evident on general grounds that the rocks may be equivalent to a portion of those in the Ramtek belt, except for the complete absence of manganese-ores and manganese-silicate-rocks and of the calc-granulites and various marbles, unless some of these latter are represented by the actinolite-schists. Allowing for this difference in composition, Mr. Bhattacharjee supposes that the differences between the two rocks are otherwise functions of intensity of metamorphism, and that the equivalents of the various types of metamorphic rocks in this belt are to be found in a more highly metamorphosed form in the belt occupied by the Sausar series in the Ramtek country to the north. The zone separating these two belts is largely covered by alluvium; nevertheless there are outcrops of rock and had there been a conglomerate, indicating an unconformity between the rocks of the two belts, exposures of

such should have been found. Further light on this problem is likely to be thrown by the next two field seasons' work in this portion of the Central Provinces.

Rewa State, Central India.

In his journey to the corundum deposits of Pipra in the south-east corner of Rewa State from Mirzapur on the East Indian Railway, Dr. Dunn records his impressions of the rocks traversed. The first rocks passed over after leaving the Gangetic alluvium were the Vindhyans. These persist to the Son River, after crossing which Archæan rocks are found. The country for the first few miles south of the Son River is made up of quartzites, banded hæmatite-quartzites, jaspery quartzites, slaty shales and innumerable basic traps, apparently contemporaneous, all striking east and west. One or two small outcrops of limestone were also seen. This series has been correlated with the Bijawars on the old map, but Dr. Dunn was struck with its similarity to the unaltered representatives of the Iron Ore series of Singhbhum. Passing south from this area of vulcanicity these rocks merge imperceptibly, without any apparent stratigraphical break, into an immense sequence of slaty shales, striking east and west from Mirzapur district into Rewa State. Near the Rehr River valley these become gradually metamorphosed and finally a gneissic-granite is passed over. In the Rehr River valley small patches of the Lower Gondwana rocks are seen to rest upon this gneissic-granite and other metamorphic rocks.

In the vicinity of Pipra the dominant rock-type is the above granite which is apparently intrusive into all the other Archæan representatives.

Apart from the gneissic granite the most abundant rock-type is hornblende-schist. Outcrops of this have been alluded to as dykes, but a close examination convinced Dr. Dunn of the intrusive relation of the granite to them. Their linear arrangement, as in other parts of India, is, in Dr. Dunn's opinion, due simply to their excellent cleavage and to the fact that the granite has intruded into and separated them along the cleavages.

In close association with the corundum deposits, the most abundant rock-type is a sillimanite-schist usually containing euphyllite, corundum, rutile and tourmaline. An enstatite-bearing rock is also found; this is an enstatite-quartz-rock with or without plagioclase felspar, and often with diopside, the two pyroxenes at

times showing an alteration to hornblende. Deep brown biotite is almost invariably present. As a further stage in the metamorphic development of these enstatite-bearing rocks, there are several types which show distinct peculiarities and occur simply as small "segregation" masses in the enstatite-bearing rock. They include pure enstatite-quartz-rocks, enstatite-cordierite-rocks, garnet-sillimanite-cordierite-quartz-rocks, garnet-diopside-quartz-rocks, etc.

It is possible that the sillimanite-schist and the corundum bed form a highly metamorphosed aluminous, perhaps bauxitic, series of sedimentary beds. The enstatite-bearing rocks, however, seem to have been derived from pyroxene-plagioclase rocks of igneous origin. Dr. Dunn remarks that it seems feasible that the aluminous clays were originally derived from this igneous rock.

Coal-fields Party.

The Coal-fields Party continued their re-survey in detail of the coal-fields of Raniganj and Jharia on the new 4 inches-to-the-mile maps. The survey of the Raniganj field was begun in the cold weather of 1925-26 and will be completed in the cold weather of 1927-28. Of the 25 sheets which cover this area 12 have been completed, 2 are awaiting the result of boring records, 3 have been partially surveyed, and the remainder lie in country where the geology is simple. The Raniganj party consisted of Rai Bahadur Sethu Rama Rau, Messrs. E. R. Gee, A. K. Banerji and J. B. Auden, Assistant Superintendents, under the control of Dr. C. S. Fox, Officiating Superintendent. Mr. Sethu Rama Rau has mapped the western end of the field and is continuing his work eastwards along the south side of the Damuda river. Mr. E. R. Gee has been working eastwards from the Barakar River and north of the Grand Trunk Road; although his work covers the most complicated tract of the coal-field he has mapped the largest area. Mr. Banerji has mapped the country astride the Barakar River and is continuing eastwards along the north of the Damuda River and south of the Grand Trunk Road. He is making a petrological study of the sedimentary strata in addition to his normal work of elucidating the structure of the upper Damuda strata. Mr. J. B. Auden was attached to the Coal-fields party for training and has proved a valuable acquisition. He has been re-examining the tract astride the Barakar River in an endeavour to arrive at a satisfactory correlation of the coal-seams on each side of the river. The delay in unravelling this area is due to lack of exposures

and a want of reliable data from bore-hole records. Two borings are to be put down shortly and it is expected that with the information thus obtained a reliable correlation will be possible. The structure has been worked out with great care by Messrs. Gee, Banerji and Auden in consultation with Dr. Fox on the ground. As a result of these visits of inspection and discussion in the field the Raniganj party have come to the conclusion that the Barakar stage is conformably overlain by the Ironstone Shale stage and that the true Barakar-Ironstone Shale boundary must lie south of the Grand Trunk Road at Begunia. An observation by Dr. Fox in regard to the false-bedding in the Barakar sandstones has provided the clue which enabled the unconformity suspected by W. T. Blanford to be satisfactorily accounted for. It has also been necessary to revise our opinion in regard to the fossil wood bed in which the specimen of *Dadoxylon* was found three years ago. It was then thought that the fossil-wood sandstone was at the base of the Panchet series in spite of the fact that the palæntological evidence indicated a Palæozoic age. Messrs. Gee and Banerjee north of the Damuda, and Mr. Sethu Rama Rau south of the same river, have found that the fossil-wood sandstone is a definite horizon throughout the middle western tracts of the Raniganj coal-field, and undoubtedly part of the Raniganj stage. Dr. Fox visited several exposures and in view of a local unconformity above the fossil-wood horizon, the evidence of the fossils, and the remarkable parallelism between the fossil-wood bed and the Narsamuda-Patmohna coal-seam below it, has come to the conclusion that the fossil-wood sandstone should be relegated to the Raniganj stage.

The new 4-inch maps of the Jharia coal-field were not available until towards the end of the season, 1926-27, when Dr. Fox began the geological re-survey of the Jharia area. Of the 8 sheets which comprise this field he has already surveyed two sheets and surveyed more than half of two other sheets. He hopes to complete the mapping of the field during the season, 1927-28. In the course of his work in the north-western corner of the Jharia field among the Talchir beds Dr. Fox found that striated or scratched pebbles were exceedingly rare among the glacial boulder beds; he observed no faceted pebbles. The pebbles consist largely of granitic material and very rarely of quartzite. There are several pebble beds in the lower Barakar stage and it was thought that these beds were resorted Talchir débris, but an examination of the pebbles shows

that they are practically all of quartzite; granite pebbles have not been noticed.

The Department is indebted to Mr. J. E. Phelps of Jealgora who spent considerable time and trouble in collecting pebbles and boulders from the sandstone overlying No. 17 coal seam in the Barakar stage in the Jharia coal-field, with a view to the elucidation of their origin. Some of the pebbles shewed distinct facets, but since nearly all of these were found to coincide with joint planes, it was the general opinion that there was no conclusive evidence of glaciation.

The coal-seams in the Barakar stage have proved to be less irregular than was imagined from previous information. It has also been found that the base of the Barakar stage includes beds which were earlier thought to be carbonaceous strata in the Talchirs. There is thus no evidence of plant fossils in the Talchirs of the north-west corner of the Jharia field as previously supposed.

The work has advanced far enough to show that there will be considerable differences in the numbering of the coal-seams with regard to the old maps, but Dr. Fox is of the opinion that a re-numbering of the seams will lead to confusion and for the present no change in the recognised number of a seam is to be made. In many cases a conglomeratic sandstone is found lying immediately on a coal-seam with large quartzite pebbles resting on the coal. The field evidence indicates that the substance of the seam must already have become coal before the pebbles were deposited on it as the pebbles have not sunk into the coal.

In addition to his work in the Raniganj and Jharia coal-fields Dr. Fox's duties in connection with the new coal-fields memoir took him to the coal and lignite areas of the Punjab, Rajputana, Baluchistan and upper Assam. In his opinion the coal of Tertiary age in north-western India is of one horizon, the so-called Laki stage (middle to lower Eocene). A great area of marshland and lagoons appear to have covered this region in Eocene times.

It is Dr. Fox's opinion that although the lignite of Palana (Bikanir State) may have accumulated on the tracts on which the vegetable matter once grew, this cannot be true of the brown coal of Isa Khel nor of the highly bituminous coal of the Salt Range and Baluchistan. In several localities the coal-seam is seen to be intercalated between shales containing marine fossils. Even in the case of the lignite of Palana it is thought likely that the vegetable material, after

conversion into mature peat, has been transported in water, probably in the form of gelatinous material, and deposited in shallow coastal lagoons or in the quiet waters of a gulf. These north-western coals are rich in volatile matter, relatively low in ash if worked cleanly, and remarkably high in organic sulphur. They are exceedingly friable and therefore do not stand transportation or weathering. They would do well for the manufacture of gas but are clearly not suitable in a raw condition for steam raising or simple combustion. If care be exercised in picking out the dull shaly coal the remainder gives a coke of fair quality.

In connection with Dr. Fox's visit to Assam, he reports that the coal-field beyond the Namchik, discovered in 1911 by Dr. E. H. Pascoe and Mr. G. Webster, is far more attractive than many have supposed. Dr. Pascoe's opinion that it is an important area has been fully proved by the work of the geologists of the Burmah Oil Company beyond Namchik, where they have found, according to their estimates, over 25 million tons of good coal in a gently inclined thick seam. The working of this seam will not involve pumping, as the seam is above the drainage level of the surrounding country. The tract is at present somewhat inaccessible. It is evidently the same seam as is found in the "Coal-Measures" of the Makum coal-field. In a new quarry, Tipong Pani, Dr. Fox found a thin band containing gastropods, including a doubtful *Natica* in a shale band above the 20-foot seam. The true age of these Assam "Coal-Measures" has never been accurately fixed but the provisional view is that they are the equivalents of the Pegus of Burma and therefore probably Miocene.

After completing his work in the Makum, Jaipur and Nazira fields, Dr. Fox visited Badarpur, where the "Coal-Measures" contain petroleum instead of coal. He accompanied Mr. H. M. Sale to the Kanchanpur boring, about 25 miles S. S. W. of Badarpur, to collect fossils from a horizon which Mr. Sale had found in 1921. Dr. Fox with Mr. Sale's assistance brought away a fair collection of fossils. These have been provisionally ascertained by Sub-Assistant P. N. Mukherji, to indicate an upper Oligocene rather than a Miocene horizon for the fossil bed and incidentally for the petroleum-bearing "Coal-Measure" beds. In the Makum field at Bara Golai near Margherita oil has been struck in a well at a depth of nearly 2,600 feet below the coal of the Coal-Measures. Dr. Fox remarks that it is thus possible that although the petro-

leum horizon is upper Oligocene the coal seams may lie in the Miocene stage. Unfortunately the gastropods found by Dr. Fox at Tipong Pani are with doubtful exceptions unidentifiable. He has, however, made a collection of fossil plants from the coal seams of the Makum and Nazira fields. These have been sent to Professor B. Sahni for identification. Dr. Fox agrees with the writer [1] that the occurrence of coal and oil in the Assam "Coal-Measures" denotes some intimate genetic connection between these two substances.

Madras.

Parts of the following Survey sheets of the Salem and North Arcot districts of Madras were mapped by Rao Bahadur M. Vinayak Rao: Nos 57 P/1, P/3, P/4 and L/13 (1 inch-to-the-mile).

The following formations were met with:—

Recent:—Alluvium of the Palar and smaller streams.

Archæan:—

Jalarpet intrusive: syenites, mottled gneisses and granites.
Charnockites: norites, leptynites and acid charnockites.
Gneisses and granites: hornblende gneisses, schists, etc.
Dharwars: quartzites and hornblende schists.

For a river of the size of the Palar the alluvium is neither widespread nor of any great thickness. There is little doubt that it has changed its course in this region. Beds of sand, conglomerate and clay are found in the valleys of streams where they debouch from the hills. Intrusives of the Jalarpet series were found extending from south of Tiruvannamalai (P/4) northward beyond Katpadi across the Palar. They consist of pink felspar pegmatites, mottled gneisses, hornblendic gneisses and syenites. Some of the dykes found in this area may be of the same age as these intrusives. The mottled gneiss with biotite mica is seen in the railway cutting between Kaniyambadi and Kannamangalam (12° 45′; 79° 9′ 30″: P/1) and also west of the road from Katpadi (12° 57′ 30″; 79° 8′) to Chittoor. It is also found extending south of Tiruvannamalai (12° 13′ 30″; 79° 4′). Near Vettavalam (P/4) is found a coarse hornblendic granite which extends westward.

In the mottled gneiss are found pebbles of charnockite (mostly norites).

---

[1] Pascoe; *Mem. Geol. Surv. Ind.*, XL, pp. 318-324.

A thin band of syenite is found near Pallikonda, where the mottled gneiss is found at the base of the hill. A quartz felsite was noticed south of Anaikattu (P/1).

Garnetiferous leptynites and acid charnockites were found by Mr. Vinayak Rao in the hills east of Vellore. The charnockites form the mass of Tiruvannamalai Hill (P/4), and seem to extend only a few miles south of Tiruvannamalai.

In sheet L/13 charnockites of the acid variety are found along the base of the hill south of the Palar river, 3 miles east of Ambur. Charnockites also form the main mass of Pallikonda hill.

Charnockites extend along the railway line in sheet P/3, and tongues of this are found intruding the older gneisses here. The southern part of Periyamalai consists mostly of intermediate charnockites. Bands of norites are found south of the Jagkudu's Lodge at Pusimalaikuppam (12° 47′; 79° 15′. P/1). Charnockites have not been noticed north of the Palar.

The older gneisses and granites are of small extent, and consist mostly of hornblendic gneisses and granitic gneisses. They are generally contorted, and in some places, such as the eastern face of the hill about 1 mile north of Kannamangalam railway station (57 P/1), are full of garnets. Contorted gneisses are found south of the road at mile 16 from Kannamangalam to Walajah Road station. The older gneisses are found in sheet P/4, where they are intruded by the mottled and hornblendic gneisses. They are also found at the base of the hills in P/3. Small bands of Dharwars with hæmatite and magnetite were noticed by Mr. Vinayak Rao on the hill east of Sottukinni east of the Cheyyar river in P/3 as well as east of Agaram Sibbandi railway station.

Bands of quartzites are found on the western slope of the Periyamalai and Carnaticgarh hills.

Attock district, Punjab.

Dr. G. de P. Cotter was placed in charge of the Punjab Party and was employed in mapping the uncompleted portion of the Attock *tahsil*, Attock district (Kala Chitta and Margala Hills, and minor intervening ranges).

Portions of sheets 43 C/5, C/6, C/9, C/10, and C/13 were mapped. This has resulted in the joining up by continuous mapping of the work done by Dr. Pascoe in the Chak Dalla and Fatehjang areas (*Mem. Geol. Surv. Ind.*, XL, pt. 3, plates 71 and 73) with the Hazara map of Mr. C. S. Middlemiss (*Ibid.*, vol. XXVI). Meanwhile the work of other members of the party has carried the geological map south-

wards over the Potwar plateau to the neighbourhood of the Salt Range. The geology, as might be expected, is very similar to that of previously mapped areas. Dr. Cotter regards the Attock Slates at Attock as the continuation westward of Mr. C. S. Middlemiss' Slate series in Hazara.

The extended map of the Kala Chitta presents few new points of interest. In the south of the range, in the area mapped by Mr. H. M. Lahiri, some identifiable fossils (belemnites, ammonites, and lamellibranchs) were found, and a collection made by Field Collector, N. K. N. Iyengar. This officer also collected some poorly preserved brachiopods from the Trias in the cutting north of the first railway tunnel south of Campbellpur (Kundian line). In the north of the Kala Chitta and in the minor more northerly ranges, the Giumal belemnite beds appear to be absent.

A feature of the Trias, which was not observed in the area mapped last year, is the presence of red ferruginous beds, which are associated with the fossiliferous marls from which the brachiopods mentioned above were collected.

North of the Kala Chitta are three minor ranges, *viz.*, the Kawa Gar, the Campbellpur Hills, and the Kheramar with its eastward extension the Hasan Abdal group of hills. The structure in all these is the fan structure, and anticlinal and synclinal crests are very frequently obliterated.

The Kawa Gar, according to Dr. Cotter, consists of isoclinally folded Trias and Giumals with a strip of Lower Nummulitics along the northern margin. Between the Lower Nummulitics and the Trias-Giumal complex is a belt of shales of uncertain age; they are later than the Giumals and older than the Lower Nummulitic Limestone, and may represent either the Lower Eocene (Ranikot) or the *Cardita beaumonti* beds. Unfortunately they are unfossiliferous. They appear to be more closely connected with the Lower Nummulitic Limestone than with the Giumals, but are separated from the former by a red bed which may correspond to the ferruginous pisolite. In the Kheramar the Giumals are missing, and also in the isolated hills which form an extension to the east, except in the Hasan Abdal Hill itself, in which the Giumals occur on the S. W. flank.

At the local base of the Lower Nummulitic Limestone at the eastern termination of the Kheramar, there are black shales with sparse nummulites; these are only exposed in stream sections,

In the Hasan Abdal Hill the base of the Lower Nummulitic Limestone is marked by a bed (6 ft.) of ferruginous pisolite and above this about 60 feet of soft nodular limestone containing echinoids; these appear to belong to a new species of *Echinolampas*, perhaps related to *E. lepadiformis* D. & S. In the Bajar Hill to the east a *Nautilus*—unfortunately specifically unidentifiable—was found from the echinoid zone.

Dr. Cotter, in the course of his survey, noticed several erratic blocks; the largest, 9 feet high, 10 feet long, and 6 feet wide, rested upon Triassic Limestone about 3½ miles east of Campbellpur. The block itself was of granite gneiss and must have travelled from a considerable distance, perhaps from the north of Hazara. Erratics have been previously noticed by Wynne, Theobald, and Middlemiss; the latter (*Mem. Geol. Surv. Ind.*, XXVI, pp. 45, 46) supposes the erratics of the Potwar near Jhand to come from a concealed ridge of Crystallines hidden beneath later deposits. This explanation will not suit the occurrence east of Campbellpur, and we are forced once more to consider the possibility of a glacial episode in the Punjab. Dr. Cotter also noticed some deposits of unsorted material and boulder beds south of Dhok Umre about 3 miles E. S. E. of Campbellpur.

If a glacial episode is the true explanation, it must be supposed that subsequent water action and denudation has all but obliterated its traces. No trace of U-shaped valleys or of *roches moutonées* remains today.

Some minor corrections of Messrs. Wadia and Lahiri's maps of last season (sheets 43 C/14, C/15, and C/11) were made.

The area geologically surveyed by Sub-Assistant H. M. Lahiri in field-season 1926-27 lies mostly in the Pindigheb but partly also in the Fatehjang *tahsil* of the Attock district and comprises the whole of Survey sheet 43 C/7 and considerable portions of sheets 43 C/2 and C/6. In 43 C/6, his work lay in continuing the surveys already made by Drs. E. H. Pascoe and G. de P. Cotter.

The geological formations met with in sheet 43 C/6 are Murree beds, the Chharat series, Lower Nummulitics, Giumal beds and Trias. The lithology is similar to Dr. E. H. Pascoe's descriptions of the various formations in the Chak Dalla area[1]. The Triassic

[1] *Mem. Geol. Surv. Ind.*, vol. XL, pp. 383—388

and Giumal beds occur as inliers in Lower Nummulitic limestone which constitutes the bulk of the Kala Chitta hills. The Triassic limestone is for the most part unfossiliferous. The ochreous limestones of the Giumals immediately underlying the Lower Nummulitic limestone are in places highly fossiliferous but the organic remains are mostly in the shape of shell-markings. Among the few identifiable fossils collected are some specimens referable to *Trigonia scabra* Lam., a species also occurring in the Cretaceous beds of Southern India. The fossiliferous ochreous limestone beds are underlain by some olive or greenish sandstone also of the Giumal series. Below this sandstone and overlying the unfossiliferous Triassic limestones is a thin bed which yielded a number of bivalves, belemnites and ammonites, the last being mostly ill-preserved. Among the fossils is a large bivalve which has been provisionally identified with *Ctenostreon proboscidea* Sow., a species occurring in the Lias of Europe. Another well-preserved bivalve is a *Gryphæa*, thought by Mr. Lahiri to be related to *G. arcuata*, another common species of the European Lias. Besides the bivalves, there are belemnites and ammonites which, when worked out, may throw further light on the age of this bed. The Murree beds exposed in the sheet belong mostly to the Basal and Lower stages of the series. Some mammalian remains were collected from these beds. One of these has been identified by Dr. G. E. Pilgrim as *Amphicyon shahbazi*, a species also found in the Gaj of the Bugti hills.

The whole of the southern half of Survey sheet 43 C/2 was surveyed. The major portion of this sheet is occupied by a sandy alluvium, outcrops of rocks being confined to the north-eastern corner and along the larger stream-courses in the western half of the sheet. The formations exposed are the Chharats and the Murree series. The Chharats occur as narrow elongated inliers in the midst of Murree beds (Basal and Lower stages) which constitute the bulk of the hills to the north and north-west of Thatta (33° 35′, 72° 13′).

The geological formations mapped in Survey sheet 43 C/7 are the Murrees and the Siwaliks (Kamlial, Chinji and Middle Siwalik stages). The lithology of the beds is similar to that of the formations in the contiguous sheet 43 C/11, described in last year's report. All the beds from Murrees to Middle Siwaliks contain vertebrate remains. Fossil wood is not infrequently met with

in the Upper Murree beds which occupy a large area in the northern half of the sheet.

The general strike of the beds in sheet 43 C/7 is E.-W. and the dips mostly northerly. Three successive strike-faults have been mapped in the sheet, in consequence of which Upper Murree beds have been brought into juxtaposition with Basal or Lower Siwalik beds to the south. These faults, with the exception of the most northerly one, are traceable along the whole width of the sheet. The most northerly fault which is the westerly continuation of the main fault observed last year as running along the south flank and foot of the Khairi Murat Hill in sheet 43 C/11, when followed westwards, is seen to die out at Nathial (33° 25′; 72° 24′), but re-appears again near the western margin of the sheet. North of the faults, the beds have a general northerly dip. South of the most southerly of the faults, the Siwalik beds are exposed first in a synclinal fold pitching east and then in the dome-structure of the Khaur anticline. The Lower Siwalik beds of the western flank of the Khaur dome dip westwards beneath Middle Siwalik beds, occurring in a synclinal trough occupying the valley of the Sil river north and north-east of Pindigheb (sheet 43 C/8).

Besides regular mapping, some revision work in the area surveyed last year, was also done during the season.

Rajputana.

During the field-season 1926-27 the Rajputana Party consisted of Dr. A. M. Heron (in charge), Mr. A. L. Coulson and Dr. S. K. Chatterjee, Assistant Superintendents, and Sub-Assistant B. C. Gupta. Mr. Coulson continued his survey of the Sirohi State, and the other members of the party worked in the Mewar (Udaipur) State.

In Mewar the undernoted 1-inch-to-1-mile sheets of the Central India and Rajputana Survey (old numbers) were worked on: 143 (Dr. Chatterjee), 144 (Dr. Heron and Dr. Chatterjee), 145 (Dr. Heron, Dr. Chatterjee and Mr. Gupta), 146 (Mr. Gupta), 172 (Dr. Chatterjee and Mr. Gupta), 173 (Mr. Gupta) and 714 (Mr. Gupta).

Mr Gupta's work in Mewar was essentially preliminary mapping south-eastwards from Udaipur City along the line of unconformity at the base of the Delhi system, and then eastwards across the plain of central Mewar occupied by phyllites of the Aravalli system, granites and mixed gneisses. For the last six weeks of the season he continued Mr. E. J. Bradshaw's mapping of the synclines of the Jasarpur

and Sabalpura hills[1] eastwards through Jaipur and Bundi State, in sheet No. 265, to their termination.

The non-porphyritic, medium-grained, pink granite (the Berach granite) with secondary chlorite representing the ferro-magnesians, which occupies large areas of the plain in the neighbourhood of Chitorgarh,[2] is, in Dr. Heron's opinion, identical with the Bundelkhand Gneiss; this is in accordance with the views expressed in the Manual of the Geology of India (p. 68). The Aravallis rest upon this with an erosion unconformity, and it is thus the oldest rock in Rajputana. To the west this granite gradually becomes, by pressure metamorphism, a grey slabby gneiss. Further to the north, N. of Unwa ("Urwas": 24° 58′; 73° 45′) is a large exposure of the dark granite gneiss which is the dominant intrusive in the gneissic plain of Ajmer and Kishengarh.

The southern edge of the Mewar plain forms part of the main watershed of India. The slope is very gentle towards the north-east, in the direction of the Ganges valley; to the south, the fall ultimately to the Gulf of Cambay is much steeper and the country is deeply dissected, affording excellent exposures, over a distance of more than 30 miles across the strike, of the rocks which form the plain. These present a typical "gneissic complex" in which igneous rocks of several types and times of intrusion, are intimately injected one with another and the whole suite welded, while still in a plastic state, into a streaky and banded composite gneiss.

The strike of the foliation varies from N.-S. to N.N.W.-S.S.E. and its dip, in the east of the tract, is westwards, and in the west, is eastwards. This does not however indicate a synclinal disposition. Over certain areas in the western portion, the foliation is almost horizontal, but high angles approaching verticality are the general rule.

In such a complex it is difficult to ascertain the relative age of the elements, as each may have reached its present position at more than one period, and also, through pressure acting on a partly solid and partly unconsolidated association, mutual intrusion *in situ* may have taken place, involving elements of different period. The under-noted succession can therefore be considered as only an approximation to the truth.

---

[1] *Rec. Geol. Surv. Ind.*, LIX, pp. 104-5.

[2] *Rec. Geol. Surv. Ind.*, LIX, p. 94, LX, pp. 116, 118.

The oldest member of the complex, in which all the others are intrusive, is believed to be a gneissic granite, with biotite in about the same relative proportion to the other minerals as in an average granite. This occurs both in large masses almost free from later intrusions, and also as a composite gneiss with pegmatite and aplite in intimate interfoliar banding. Around the borders of the intrusion free masses in many cases occur which may be interpreted as sheets of the gneissic granite detached by the pegmatite and aplite. Towards the east the gneissic granite is either absent, or has become less biotitic. In the latter case it is probable that its place is taken by a medium-grained granite, little foliated and poor in mafic minerals; this, however, may belong to the pegmatites and aplites, intermediate in grain between them. It has a certain resemblance to the Bundelkhand Gneiss, but this may be purely accidental. In places a fine-grained, unfoliated granite carrying biotite occupies large areas ; this may be a fine variety of the fundamental gneissic granite.

The next in age, according to Dr. Heron, are probably the epidiorites and hornblende schists, resulting from the metamorphism of dolerite or other basic rocks. They are usually in large lenses and sheets, parallel with the general foliation, though small-scale banding with the other elements occurs in a minor degree.

In general younger than these, but no doubt belonging to more than one period, are the pegmatites and aplites, which grade insensibly into each other. Unlike the post-Delhi pegmatites, these rarely contain tourmaline or muscovite and they are never so coarse nor in such large bodies as the post-Delhi pegmatites. They all show markedly the effects of compression, and occur, for the most part, as sheets parallel to the oliation, of all sizes from a width of many feet down to a few inches. With the gneissic granite, and to a less extent with the hornblende schists, they produce composite gneisses of very variable aspect.

Last of all are the quartz veins. *In the present area,* Dr. Heron remarks, they are the only intrusives which penetrate the overlying outliers of Delhis and the Aravalli phyllites. Quartz veins have probably accompanied all the acid rocks, but those in the sedimentary series are of course of a much later epoch than those coeval with the igneous rocks of the complex, from the denudation products of which the sedimentaries were laid down.

To the east the Aravalli phyllites rest upon the rocks of the complex with what appears to be an erosion unconformity, from the

evidence of the single section which Dr. Heron has been able to find so far. To the west the main syncline of the Delhi system, with a clear erosion unconformity at its base, several outliers of the Delhi system (probably of the Raialo series) are disposed in two elongated isoclinal synclines, running north and south, not usually more than a mile wide, and one of them has been mapped by Dr. Chatterjee and Mr. B. C. Gupta at intervals for more than 30 miles along the strike. At Bhindar (24° 30′ : 74° 14′), on this syncline, basal grits and arkose, derived from the gneisses, indicate the unconformity.

The relationship of the Bundelkhand Gneiss to the mixed gneisses of the complex is not yet known, as it has so far not been found in contact with them.

The unconformity at the base of the Delhi system has this year been traced, in a general way, to the southern frontier of Mewar, though much detailed work has still to be done in the coming field-season.

The tract of complicated folding and faulting north of Udaipur City has yielded important results. It is found that the Rajnagar marble,[1] with the schists and basal quartzite below it and other sch'sts above it, emerges from below the basal conglomerates of the main Delhi syncline, and outliers of these conglomerates rest both upon the marble and the associated schists, and upon the mixed gneisses which unconformably underlie the marble series.

As Dr. Heron points out, there is thus a double erosion unconformity, the Rajnagar marble with its associated schists and basal quartzite resting upon the mixed gneisses, and the basal conglomerates and quartzites of the main Delhi syncline overlapping both.

There is little doubt that the Rajnagar marble and its associates are identical with the white dolomitic limestone of the Jazarpur and Sabalpura hills, and of the Pur-Banera ranges, of Sawar in the extreme south of the Ajmer district,[2] and of numerous other small outliers scattered over the central plain.

In Dr. Heron's opinion the correlation may with safety be carried still further, to link up with the Raialo limestone and quartzite, which in the south of the Alwar state locally intervenes between the base of the Alwar series and the underlying granite.[3]

---

[1] *Rec. Geol. Surv. Ind.*, LX, pp. 110-1.
[2] *Rec. Geol. Surv. Ind.*, LX, pp. 117-9.
[3] *Mem. Geol. Surv. Ind.*, XLV, pt. 1, pp. 23-8.

In Alwar the Alwar series and the Raialo series appear to be conformable, as there is no visible discordance of bedding, but the lowest beds in the Alwars are conglomerates, indicating surface conditions and a break in the succession [1], and the unconformity is probably present here also.

In Jodhpur State, on the other side of the great Delhi syncline, Mr. Tipper and Dr. Heron mapped extensive deposits of crystalline limestones which have a similar relationship with the Delhis and the basement of gneiss, and these may now be equated, with more than probability, with the Raialo limestone and the Rajnagar marble.[2] Further, the celebrated Makrana marble, which lithologically is very similar to the Raialo limestone, lies along the strike of the Ras limestones, though separated from them by many miles of alluvium and blown sand, and is considered by Mr. Tipper to be a continuation of them.

A wide-spread, but quite probable, correlation is thus advocated between all these occurrences of white dolomitic limestone in Rajputana, bringing them all under the Raialo limestone. As, in Mewar, the limestone has, both above and below it, considerable thicknesses of other rocks, the association may be termed the Raialo series, and may provisionally be considered as the lowest division of the Delhi system, separated from the Alwar series by a distinct unconformity, which, however, is not of such a magnitude as the profound unconformity between the Delhi and the Aravalli systems.

At the beginning of the season Mr. Coulson was engaged on water-supply questions at Dabheji-Jungshahi (North-Western Ry.), Tirth Laki and Gopang in Sind, and, while on his return from Sirohi to headquarters, investigated the water-supply of Jhansi.

About 455 square miles of Sirohi State were geologically mapped during the season, on the 1-inch-to-1-mile Central India and Rajputana Survey sheets 77, 95, 96, 97 and 120 (old numbers); this is in continuation of the previous season's field-work.

The sedimentary rocks present consist of limestones and calcic rocks, mica-schists, phyllites and slates, and quartzites, and these are highly metamorphosed and profusely intruded by igneous rocks. In the hilly country to the south-east of Abu Road Railway Station, these sedimentary metamorphics are seen to be thrown into isoclines

---

[1] *Loc. cit.*, pp. 48-50.
[2] *Rec. Geol. Surv. Ind.*, LVI, p. 52.

and overfolds. The quartzite to the south-east of Bandia Gadh (24° 25′ : 72° 51′) is faulted into juxtaposition with the limestone on the former's northern and eastern boundaries, and brecciation has taken place along the junction between mica-schists and limestone from Abu Road, south-eastwards.

The Erinpura granite, which has been described in last year's General Report,[1] stretches south-west from the *massif* of Mount Abu into Palanpur State, where it forms the high Jaira hills. Mica-schists are found as patches surrounded by granite and represent portions of the roof of the great bathylith.

A large mass of a younger granite occurs in the south-eastern corner of the state, where it adjoins the Idar and Danta states. Mineralogically this is very similar to the Isri [2] and Waloria [3] granites and is thus probably to be referred to the Jalor granite of LaTouche.

In the south-western area of Sirohi State, especially near Padar (24° 29′ : 72° 31′) numerous dykes, striking E.—W., form a network with the schists and limestones striking N. E.—S. W. They cut the quartz (pegmatitic) veins from the Erinpura granite, and are thus younger than it, and may be provisionally considered as hypabyssal feeders of the Malani rhyolites. Mineralogically they are composed of sericitised potash felspar, hornblende, a little quartz, and a varying amount of iron-ore, and are rather basic microgranites, the fine-grained equivalents of the Isri (Jalor) granite to the northeast.

Two occurrences of an interesting rock new to this area were noted one mile south-east of Karari (Abu Road Railway Station) and at Chaudrawati (24° 26′ : 72° 47′); this varies from almost a troctolite (olivine and labradorite) to an olivine-gabbro (olivine, titaniferous augite and labradorite.

BIBLIOGRAPHY.

The following papers dealing with Indian geology and minerals were published during the year 1927 :—

ADAMS, F. D. . . . A Visit to the Gem Districts of Ceylon and Burma. *Trans. Canad. Inst. Mining Metallurgy*, XXIX, 1-34.

---

[1] *Rec. Geol. Surv. Ind.*, LX, pp. 112-5.
[2] *Ibid.*, LX, p. 114.
[3] *Rec. Geol. Surv. Ind.*, LIX, p. 103.

ADAMS, F. D. AND GRAHAM. — On some Minerals from the Ruby Mining District of Mogok, Upper Burma. *Trans. Roy. Soc. Canada*, Ser. 3, XX, Sect. IV, 113-136.

AHMED, K. M. . . — On two types of fossil wood from the Utatur Cretaceous, Trichinopoly District. *Proc. Fourteenth Ind. Sci. Congr.* (*As. Soc. Bengal*), 237 (abstract).

ANON . . . . . — Oil in Iraq. *Mining Mag.*, XXXVII, 270-271.

BENSON-COOKE, LIEUT-COL. G. — The Future of Oil in Burma. *Petrol. Times*, XVIII, 758.

BHATTACHERJEE, R. C. . — Low Temperature Carbonisation of Indian Coal. *Quart. Journ. Geol. Min. and Met. Soc. India*, I, 101-113.

BOWEN, N. L. . . . . — An analcite-rich rock from the Deccan traps of India. *Journ. Washington Acad. Sci.*, XVII, 57-59.

BRAHMACHARI, U. N. AND S. C. — Two Neolithic Stone Implements found in a Tank at Jamalpur (Monghyr). *Journ. and Proc. As. Soc. Bengal*, New Series, XXII, 135.

BROWN, J. COGGIN . . — Indian Coal Problems. *Bull. Ind. Industries and Labour*, No. 36.

CADMAN, SIR JOHN . . — The Development of the Petroleum Industry in Persia. *Journ. Roy. Soc. Arts*, LXXV, 430-435.

Caldwell, G. S. and Lomax, James. — Notes on Indian Mining or Experiences at an Indian Colliery. *Trans. Inst. Mining Eng.*, LXXIV, 59-70.

Chatterjea, N. N. . — On three Deep-Sea Deposits from the Bay of Bengal. *Journ. Dept. Science, Calcutta University.* IX, 19-26.

Chhibber, H. L. . . — (*a*) Metamorphic Rocks and Minerals of the Copper Deposit near Amba Mata, Danta State, North Gujarat, India. *Trans. Min. Geol. Inst. India*, XXI, 129-143.

(*b*) The Igneous Rocks of the Mount Popa Region, Burma. *Ibid.*, 226-310.

(*c*) Some Intrusive Rocks of the Pegu Yoma, Burma. *Ibid.*, 338-363.

(*d*) Rhythmic Banding of Ferric Oxide in Silicified Rhyolite Tuffs. *Geol. Mag.*, LXIV, 7-10.

(*e*) The Extinct Iron Industry of the Neighbourhood of Mount Popa, Uppoe Burma, with Notes on the Microscopic Study of the Slags. *Journ. and Proc. As. Soc. Bengal*, New Series, XXII, 219-233.

(*f*) The Rhyolites and Rhyolite Tuffs of Thaton District, Lower Burma. *Proc. Fourteenth Ind. Sci. Congr.* (*As. Soc. Bengal*), 239 (abstract).

(*g*) The Serpentines and the associated minerals of Henzada and Bassein districts, Burma. *Ibid.*, 239-240 (abstract).

CLEGG, E. L. G. . . (*a*) Notes on a Geological Traverse in the Yunzalin Valley. *Rec. Geol. Surv. Ind.*, LX, 292-302.
(*b*) Ambala Boring of 1926-27. *Ibid.*, 303-307.

COSSMANN, M., PISSARRO, G., VREDENBURG, E., AND COTTER, G. DE P. The Mollusca of the Ranikot Series (together with some species from the Cardita Beaumonti Beds). *Pal. Ind.*, New Series, X, No. 2.

COTTER, G. DE P. . . (*a*) The Distribution of the Gault in India. *Rec. Geol. Surv. Ind.*, LIX, 405-409.
(*b*) The Age of the so-called Danian Fauna from Tibet. *Ibid.*, 410-418.

COULSON, A. L. . . The Geology of Bundi State, Rajputana, *Rec. Geol. Surv. Ind.*, LX, 164-204.

CROOKSHANK, H. . . Oil Indications at Drigh Road near Karachi. *Ibid.*, 157-159.

DAS-GUPTA, H. C. . . (*a*) Notes on the Geology of the Island of Bombay. *Journ. Dept. Science, Calcutta University*, VIII, 123-128.
(*b*) Palaeontological Notes on the Panchet Beds at Deoli, near Asansol. *Journ. and Proc. As. Soc. Bengal*, New Series, XXII, 215-217.
(*c*) Batrachian and reptilian remains found in the Panchet Beds at Deoli, Bengal. *Proc. Fourteenth Ind. Sci. Congr. (As. Soc. Bengal)*, 240 (abstract).

DAVIES, MAJOR, L. M. . (*a*) On the discovery of an Indian species of Blanckenhorn's genus *Dictyoconus*. *Proc. Fourteenth Ind. Sci. Congr. (As. Soc. Bengal)*, 241-242 (abstract).

DAVIES, MAJOR L. M. . (*b*) The Ranikot Beds at Thal (North-West Frontier Provinces of India). *Quart. Journ. Geol. Soc.*, LXXXIII, 260-290.

(*c*) Supplement to "Notes on the Correlation of Pinfold's Chharat Series with the Eocene Stages of Sind and Europe." *Trans. Min. Geol. Inst. India*, XXI, 313-321.

DAVIS, H. J. . . . The Occurrence of Cassiterite in South Amherst, Tenasserim, Lower Burma. *Mining Mag.*, XXXVII, 26-29.

FERMOR, L. L, . . (*a*) Kata-Metamorphism or Hypo-Metamorphism. *Geol. Mag.*, LXIV, 334-336.

(*b*) Magnetic Properties of Minerals. *Mining Mag.*, XXXVII, 296.

FOX, CYRIL S . . The Occurrence of Low-Phosphorus Coking Coal in the Giridih Coal-Field. *Rec. Geol. Surv. Ind.*, LIX, 371-404.

GEE, E. R. . . . Geological Aspects of the proposed Kangra Valley Railway (Punjab and Mandi State). (*North-Western Railway Press, Lahore*).

HERBORDT, O. . . (*a*) Mitteilung über einen alten Bleierzbergbau im Ghorbandtal (Afghanistan). *Zeitschr. Prakt. Geol.*, XXXIV, 156-160.

(*b*) Eine Reise nach "Där-i-Nur" im Nordosten Afghanistan. *Peterm. Mitt.*, LXXII, 206-208.

(*c*) Über die Aussichten Afghanistans als Bergbauland. *Intern. Bergwirtschaft*, I, 269-273.

HOBSON, G. V. . (*a*) Six Recent Indian Aerolites. *Rec. Geol. Surv. Ind.*, LX, 128-152.

(*b*) Sand Supply in the Upper Damodar River. *Trans. Min. Geol. Inst. India*, XXI, 324-337.

HUTTON, J. H. . . A Naga Hills Celt. *Journ. and Proc. As. Soc. Bengal,* New Series, XXII, 133.

KREJCI, KARL. . . Zur Geologie des Persischen Golfes. *Centralbl. Miner. Geol. Palæont.,* 1927, Abt. B, 287-294.

KRISHNAN, M. S. . . Bauxite on Korlapat Hill, Kalahandi State, Bihar and Orissa. *Rec. Geol. Surv. Ind.,* LIX, 419-422.

LEES, G. M. . . . Pliocene Oil Seepages in Persia. *Journ. Inst. Petrol. Techn.,* XIII, 321-324.

MAHADEVAN, C. . . Pleochroic Haloes in Cordierite. *Ind. Journ. Physics,* I, 445-456.

MATHER, RICHARD . . The Iron and Steel Industry in India. *Journ. Roy. Soc. Arts.,* LXXV, 600-624.

MEINERTZHAGEN, COL. R. . Ladakh, with special reference to its Natural History. *Geog. Journ.,* LXX, 129-163.

PASCOE, E. H. . . (*a*) General Report for 1926. *Rec. Geol. Surv. Ind.,* LX, 1-127.
(*b*) The Mineral Production of India during 1926. *Ibid.,* 205-291.
(*c*) A Gas Eruption on Ramri Island, off the Arakan Coast of Burma, in July. 1926. *Ibid.,* 153-156.

PILGRIM, GUY E. . . (*a*) A Sivapithecus Palate and other Primate Fossils from India. *Pal. Ind.,* New Series, XIV.
(*b*) The Lower Canine of Tetraconodon. *Rec. Geol. Surv. Ind.,* LX, 160-163.

PINFOLD, E. S., DAY, A. E., STAMP, L. D. AND CHHIBBER, H. L. — Late Tertiary Igneous Rocks of the Lower Chindwin Region, Burma. *Trans. Min. Geol. Inst. India*, XXI, 145-225.

PRASHAD, B. . . . On some Fossil Indian Unionidæ. *Rec. Geol. Surv. Ind.*, LX, 308-312.

PRINZ, GYULA . . . Beiträge zur Glaziologie Zentralasiens. *Mitt. Jahrb. K. Ungar Geol. Anstalt.*, XXV, 127-335.

RAO, B. BALAJI . . . Report on some blocks in the Kolar and Bangalore Districts, 1923-24. *Rec. Mysore Geol. Dept.*, XXIV, 63-91.

RAO, B. RAMA . . . (*a*) Notes on the Geological Features of the Maddur Malvalli Region with special reference to Rocks of the Charnockite affinities. *Ibid.*, 92-133.

(*b*) The "Kodamites" or the Cordierite Micaceous Gneisses of Channapatna area. *Ibid.*, 134-152.

RAO, C. R. NARAYAN AND SESHACHAR, B. R. — A Short Note on certain Fossils taken in the Ariyalur Area (S. India) *Half-yearly Journ. Mysore University*, I, 144-152.

RAO, L. RAMA . . . (*a*) Notes on the Upper Cretaceous Rocks near Ariyalur (S. India). *Half-yearly Journ. Mysore University* I, 153-157.

(*b*) Stigmatopygus vs. Cyrtoma, a discussion in nomenclature. *Proc. Fourteenth Ind. Sci. Congr. (As. Soc. Bengal)*, 237 (abstract).

RAO, S. L. . On a new type of Cassidulidae from the Upper Cretaceous rocks near Ariyalur. *Proc. Fourteenth Ind. Sci. Congr. (As. Soc. Bengal)*, 237 (abstract).

REED, F. R. COWPER . Palæozoic and Mesozoic Fossils from Yun-nan. *Pal. Ind.*, New Series, X, No. 1.

REES, W. J. . . . Some Notes on the Use of Indian Sillimanite. *Quarry,* XXXII, 287-289.

RICHARDSON, R. K. . . Die Geologie und die Salzdome im südwestlichen Teile des persischen Golfes. *Verh. Naturh.—Med. Verein Heidelberg.* N. F. XV, 1-49.

ROY, S. K. . . The Punjab Government hydro-electric power plant at Mandi and its bearing on the mineral resources of the Mandi State. *Proc. Fourteenth Ind. Sci. Congr.* (*As. Soc. Bengal*) 241 (abstract).

SEN, A. M. . . . Report of work done during the Field Season of 1923-24. *Rec. Mysore Geol. Dept.*, XXIV, 29-62.

SEN, J. . . . . Fossil wood from the Lalmai Range in Comilla, Bengal. *Proc. Fourteenth Ind. Sci. Congr.* (*As. Soc. Bengal*), 240 (abstract).

SOHNI, V. V. . . Mud Volcanoes of Minbu, Upper Burma. *Nature*, CXX, 586.

SPATH, L. F. . . . Revision of the Jurassic Cephalopod Fauna of Kachh (Cutch). *Pal. Ind.*, New Series, IX, No. 2. Part I.

STAMP, L. D. . . (*a*) The Conditions Governing the Occurrence of Oil in Burma. *Journ. Inst. Petrol. Techn.*, XIII, 21-70.

(*b*) The Geology of the Oil Fields of Burma. *Bull. Amer. Assoc. Petrol. Geol.*, XI, 557-579.

STAMP, L. D. . . . (c) The oil fields of Burma: Recent advances in geological knowledge. *Proc. Fourteenth Ind. Sci. Congr.* (*As. Soc. Bengal*), 227-236.

STAMP, L. D. AND CHHIBBER, H. L. The Igneous and Associated Rocks of the Kabwet Area (Shwebo and Mandalay Districts), Upper Burma. *Trans. Min. Geol. Inst. India*, XXI, 97-128.

STUART, MURRAY . . The Petroleum Industry of Burma. *Petroleum Times*, XVII, 1023-1024.

SWAMINATHAN, V. S. . (a) Kyanite from Nellore. *Proc. Fourteenth Ind. Sci. Congr.* (*As. Soc. Bengal*), 237-238 (abstract).

(b) Notes on the mode of occurrence and composition of beryl from Nellore. *Ibid.*, 238 (abstract).

(c) Petrological notes on (a) granitic and gneissic rocks, and (b) quartz-augite-porphyrite from Nellore, Madras. *Ibid.*, 238-239 (abstract).

VENKATARAMAIYA, B. N. . Report on work done during the Field Season of the year 1923-24. *Rec. Mysore Geol. Dept.*, XXIV, 153-160.

VREDENBURG, E. . . A Review of the Genus Gisortia with descriptions of several species. *Pal. Ind.*, New Series, VII, No. 3.

WARD, F. KINGDON . (a) A Note on Deglaciation in Tibet. *Geol. Mag.*, LXIV, 278-281.

(b) The Riddle of the Tsangpo Gorges. *London: Edward Arnold & Co.*

YANESKE, B. . . . The manufacture of steel in India by the Duplex process. *Journ. Iron & Steel Inst.*, CXV, 181-210, 767-769.

ACTINODON RISINENSIS, N. SP. IN THE LOWER GONDWANAS OF VIHI DISTRICT, KASHMIR, BY D. N. WADIA, *Assistant Superintendent, Geological Survey of India.* AND W. E. SWINTON, *British Museum, London.*[1] (With Plate I.)

The present fossil was found in a small outcrop of Lower Gondwana rocks near the Risin hamlet (1½ mile E.N.E. of Zewan, Vihi district, Kashmir), not far from the site from which Noetling obtained plant and vertebrate fossils in 1902 (described by Seward and Woodward in *Pal. Ind.*, New Series, Vol. II, Mem. 2, 1905). The *Actinodon* skull occurs in association with numerous remains of fossil Ganoid fish and pteridospermous plants in a series of beds of remarkable petrographic constitution, which look exactly like, and have hitherto been described as black carbonaceous shales, but which in reality are extremely pure glassy volcanic tuffs, finely laminated for the most part.

Introduction.

The importance of the present find, besides the purely palæontological interest, lies in the association of indubitable Lower Gondwana fossils with a rock-group of this peculiar lithology, a circumstance which helps in fixing an important stratigraphical horizon in the Punjab range of the middle Himalaya. For a similar group of volcanic glassy tuffs and slates occurs conformably at the base of a very thick series of unfossiliferous coarse sediments, along the S.W. flank of the Pir Panjal; this latter series has been, on various grounds, ascribed to the Lower Gondwana by one of the present writers,[2] but positive evidence was lacking as the series did not yield a single indubitable fossil plant or animal.

The stratigraphical sequence in the Pir Panjal recalls in its main elements that in the Vihi district and, as Middlemiss' work has tended to prove, occurs in fact in the south-western limb of the geosynclinal of the Kashmir valley.[3] The occurrence, therefore, of the present

---

[1] The stratigraphical account in the above paper is written by Mr. Wadia who collected the fossil; the palæontological description is by Mr. Swinton.

[2] *Mem. Geol. Surv. Ind.*, Vol. LI, Pt. 2.

[3] *Rec. Geol. Surv. Ind.*, Vol. XL, Pt. 3; and *Rec. Geol. Surv. Ind.*, Vol. XXXVII, Pt. 4.

fossil in a rock-series of this peculiar nature in Vihi establishes, with reasonable approximation, the Lower Gondwana age of the Pir Panjal sediments, which overlie it with perfect conformity, but which in all other respects are unlike the Vihi sediments. For, while in the Vihi area the overlying Gondwanas are barely 50 feet thick and are composed of fine-grained siliceous shales with limestones, the Panjal Gondwanas are composed of coarse conglomerates, sandstones, and sandy shales, over 5,000 feet in thickness.

Stratigraphy.

The following section, pieced together from the closely adjacent Risin and Zewan outcrops (situated about 1 mile apart, along the same strike-line) gives the stratigraphical relations of the fossil locality:

Strike E.N.E. to N.E. Dip 30°.

Zewan stage (Permo-Carboniferous).	Sandy, thick-bedded, grey limestone with *Athyris*, *Productus*, *Protoretepora*, etc., showing rapid but perfectly conformable passage into	
Gangamopteris beds (Upper Carboniferous).	Dense, black, slaty tuff (grey or buff on exposure) containing many plants, fish, *Archegosaurus*, *Actinodon*.	100 feet
	Thin lenticular limestone and chert bands .	10 ,,
	Black flaggy and laminated glassy tuffs, ringing under the hammer, with *Gangamopteris* only	20 ,,
	Black, coarsely crystallised limestone, showing metasomatic change into flint . . .	4 ,,
	Green siliceous shales	3 ,,
	———————————————————	Conformity
Panjal Trap (Upper Carboniferous).	Amygdaloidal bedded basic lava flows . .	

The fossil fishes belong to the genus *Amblypterus*—*Amblypterus kashmirensis* A. S. W., *Amblypterus symmetricus* A. S. W., *Amblypterus* sp. indet.—and consist of impressions of cranial, abdominal and caudal regions with recognisable elements of the skulls and limbs.

The plant remains associated with the *Actinodon* are:—

Gangamopteris kashmirensis.
Gangamopteris sp.
Glossopteris indica.
Vertebraria indica.
Callipteridium sp.
Cordaites sp.
Psygmophyllum sp.
Ginkgo sp.

The chief fossiliferous zone is made up of the upper tuffs which are exposed in a series of small dip-slopes over the whole length of the hill-face, the dip of the beds—about 30°—corresponding with the slope of the latter. The lower tuffs have so far yielded only fragments of *Gangamopteris* leaves. Both these tuffs have been hitherto spoken of as carbonaceous shales, the presence of plants being assumed as sufficient evidence of the carbon content. But there is neither clay nor carbon in them, as a microscopic examination shows. The rock is wholly composed of glass particles with a few tiny crystals of felspars. The black colour is due to iron and bleaches rapidly on all exposed parts. The rock gelatinises easily with acids and splinters on the application of heat.

The rapid but perfectly conformable passage of the tuffs into the *Productus*-bearing limestone of the Zewan stage is conclusive evidence of the Upper Carboniferous age of *Actinodon risinensis.*

The specimen consists of a piece of matrix bearing the impression of the greater part of the upper surface of a Stegocephalian skull. The skull has been slightly flattened and traces of the mandibles with teeth are observable on its lateral borders. About half of the post-orbital region and the tip of the snout are missing. Despite this the condition of the features preserved is sufficient to indicate that the species is new. The general proportions are very similar to those of *Actinodon,* to which genus we propose to refer the specimen. This genus was established in 1867 by Gaudry (*Nouv. Arch. du Mus. Paris,* 1867, Vol. iii, p. 23) for some material from Autun to which, however, he gave no specific name. In the same paper (*loc. cit.*, p. 31) he drew attention to the similarity between *Actinodon* and *Archegosaurus latirostris* and figured the latter as *Actinodon latirostris.* which, accordingly, became the type species, although later French writers overlook it as such. Gaudry subsequently established the forms, *A. frossardi* (*Bull. Soc. Géol. de France,* 1868) and *A. brevis* (Les Enchainements du monde animal—fossiles primaires, Paris, 1883, p. 266). In 1910 Thévenin (*Ann. de Palaeont.*, 1910, Tome V, fasc. 1) redescribed and figured the two latter forms and showed that they represent different growth stages of a single species. The new specimen is closely similar in size to the *Actinodon brevis* stage but various features prevent its reference to any growth stage of the type species. From the locality of its occurrence we propose to name it *Actinodon risinensis.*

Palæontological account.

Genus: ACTINODON Gaudry.

ACTINODON RISINENSIS, sp. nov.

Diagnosis.—Skull slightly longer than broad with the lateral borders more convex than in the type species; orbits comparatively large and in the middle of its length the squamosal much narrower than in *A. latirostris*; squamosal border of the otic notch running more backwardly. Fronto-parietal suture anteriorly placed.

Material.—Impression of the greater part of the upper surface of the skull. Holotype. In the collection of the Geological Survey of India.

Horizon and Locality.—Permo-Carboniferous—basal Gondwana. Zewan Spur, Vihi, Kashmir, India.

Dimensions.

	A. risinensis.	*A. brevis* (Gaudry's fig.)
Maximum length	93 mm.	94 mm.
Length along middle line	78 „	78 „
Maximum breadth	86 „	88 „
Breadth of hinder border of squamosal	11 „	18 „
Breadth across posterior edge of orbits	72 „	73 „
Breadth across middle of orbits	64 „	64 „
Breadth across anterior edges of orbits	58 „	58 „
Length of orbits	21 „	17 „
Breadth of orbits	17 „	13 „
Inter-orbital breadth	15 „	13 „
Diameter of parietal foramen	3 „	..
Breadth of skull across nares	33 „	33 m.m.

Description.—The region of the skull posterior to a line joining the hinder borders of the left squamosal and the right orbit is missing, as also is the tip of the snout with the left narial opening. The impression of the greater part of the skull is, however, quite well preserved. In general size and shape it closely resembles *A. brevis* although the lateral borders of the skull are more convex than in that form and resemble those of *A. frossardi.* The whole surface is covered with a fine ornamentation in the form of small rounded pits, which occasionally—and especially in the nasals—show a radial arrangement. The impression of the left squamosal is complete and is chiefly remarkable for its narrowness, being little more than half the width of that of *A. brevis.* The squamosal border of the

otic notch is, and the notch itself appears to be, directed more backwards and to a less degree outwards than in the type species. The remaining bones of the skull call for no detailed description. The sutures are discernable with some clearness on treating the impression with a solution of Canada balsam in xylol and are reproduced as far as traceable in figure 1, Plate 1. The parietal bone is comparatively large, the fronto-parietal suture being placed further forwards than in the figures of *A. frossardi* or *A. brevis.* In Thévenin's figure of *A. frossardi* the suture is practically coincident with the line joining the posterior borders of the orbits. The parietal foramen is circular with a diameter of 3 mm. The orbits, situated in the middle of the length, are ovate and have their long axis parallel to the lateral borders of the cranium. They are comparatively large, their length being approximately two-ninths of the maximum length of the skull as against two-elevenths in the case of *A. brevis.* The impression of the right naris is completely preserved and is comparatively large; it is close to the rostral border and has its long axis directed forwards and inwards. The characters of the mandible are well seen in a cast made from the impression and are closely similar to those figured for the type species. The teeth are narrowly conical and measure about 4 mm. in length. The remaining features to be seen in the specimen are quite similar to those of the skulls described by Gaudry and Thévenin and call for no further description.

The occurrence of this new form in the locality which has already yielded the remains described as *Archegosaurus ornatus* by Smith Woodward (*Pal. Indica,* New Series, Vol. II, Mem. 2, p. 13) is interesting and it is to be hoped that further specimens from this stegocephalian fauna will be forthcoming.

EXPLANATION OF PLATE

PLATE I. *Actinodon risinensis,* sp. nov. Upper surface of the skull as drawn from the pression, natural size. The broken line indicates restored portions. Sq.=squamosal; Au.=auditory notch; Pa.=parietal; P. f.= parietal foramen; Fr.=frontal; Orb.=orbit; Na.=nasal; Nar.=narial aperture.

MISCELLANEOUS NOTE.

Further Note on the Nomenclature of Hollandite.

In a paper[1] published some years ago I proposed the institution of a new group of minerals to include the crystalline mineral hollandite, its amorphous form psilomelane, and coronadite, a fibrous mineral described by W. Lindgren and W. F. Hillebrand, from the Clifton-Morenci copper area of Arizona, United States of America, the last-named mineral being regarded by me as a manganese-lead manganate, instead of as a manganite, as thought by the authors of the term. In a later paper[2] recognition was accorded to Prof. Lacroix' term romanéchite, applied to the mineral obtained from Romanèche in Central France, and it was shown that romanéchite could be suitably recognised as one variety of hollandite, if again it were regarded as a manganate, instead of as a manganite as interpreted by the author.

A discussion of the nomenclature of these minerals was summarised in the following statement:—

$$\text{Hollandite Group}\left\{\begin{array}{l} \left.\begin{array}{l}\text{Pb low or absent}\\ \text{Ba low to high}\end{array}\right\}\text{Hollandite}\left\{\begin{array}{l}\left.\begin{array}{l}\text{High in } H_2O\\ \text{Low in } Fe_2O_3\end{array}\right\}\text{Romanéchite.}\\ \left.\begin{array}{l}\text{Low in } H_2O\\ \text{High in } Fe_2O_3\end{array}\right\}\text{Hollandite } \textit{sensu str.}\end{array}\right.\\ \left.\begin{array}{l}\text{Pb high}\\ \text{Ba absent or low}\end{array}\right\}\text{Coronadite}\end{array}\right.$$

At this stage the problem remained until 1923,[3] when Ernest E. Fairbanks published the results of a microchemical study of polished sections of coronadite, romanéchite, and hollandite. These tests showed that both coronadite and romanéchite are mixtures of hollandite with an unidentified finely disseminated constituent.

The results of this work simplify greatly our nomenclature; for although the work of Fairbanks does not tell us whether the high lead contents of coronadite is contained in the hollandite or in the other mineral present, it enables us to reject the name as that of a mineral species. The same remark applies to romanéchite, and we can now with confidence use the term hollandite as a comprehensive term for all the known varieties of crystalline manganates. It will be time enough to admit varieties or sub-species of hollandite, when satisfactory chemical evidence of the existence of varieties of unusual composition is forthcoming.

L. L. FERMOR.

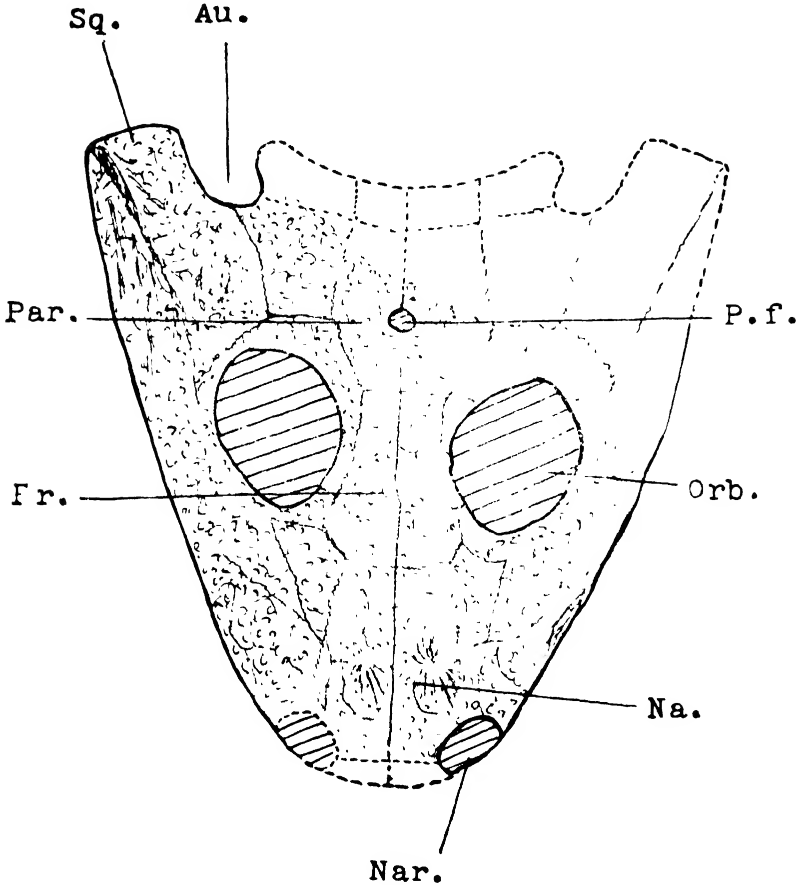
---

[1] *Rec. Geol. Surv. Ind.*, XXXVI, pp. 295-300, (1908).

[2] 'On the Crystallography and Nomenclature of Hollandite'. *Rec. Geol. Surv. Ind.*, XLVIII, pp. 103-120, (1917).

[3] 'Micrographic Notes on Manganese Minerals'. *Amer. Mineralogist*, Vol. 8, p. 209, (1923).

MGIPC—M—V-2-10—5-6-28—800.



G. S. I Calcutta.

ACTINODON RISINENSIS, *SP. NOV.*

(Natural size)

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2] 1928 [August

A CONTRIBUTION TO THE GEOLOGY OF THE PUNJAB SALT RANGE. BY CYRIL S. FOX, D. SC., M. I. MIN. E., F.G.S., *Officiating Superintendent, Geological Survey of India.* (With Plates 2 to 18.)

I.—INTRODUCTION.

So much has been written on the geology of the Punjab Salt Range that it would have been remarkable if no controversy had arisen. Like most geologically classic areas it has attracted considerable attention. Field observations in connection with the geology of the range are valuable. This is one of my excuses for adding to the literature. Another is that by visiting this most interesting region I was obliged to change my opinions in regard to the structure of the range and the geological age of the salt-bearing strata which are exposed at the base of the great scarp from the Jhelum to the Indus at Kalabagh. It should be stated, however, that this contribution does not receive the full support of my colleagues.

The Punjab Salt Range was geologically surveyed by A. B. Wynne in 1869-71[1]. It has never been systematically surveyed since. Wynne also surveyed the salt-bearing region of the Kohat district during the season 1873-74[2], and mapped the trans-Indus extension of the Salt Range in 1878-79[3]. (See Figures 1 and 2.) H. Warth[4] had a local knowledge of the Salt Range and Kohat,

[1] *Mem. Geol. Surv. India*, XIV, 1878, "On the Geology of the Salt Range in the Punjab."

[2] *Mem. Geol. Surv. India*, XI, pt. 2, 1875, "The Trans-Indus Salt Region in the Kohat District, with an appendix on the Kohat Mines or Quarries, by H. Warth."

[3] *Mem. Geol. Surv. India*, XVII, pt. 2, 1880, "On the Trans-Indus Extension of the Punjab Salt Range."

[4] *Mem. Geol. Surv. India*, XI, pt. 2, 1875, p. 2.

extending over a perio l of 20 years, which was unrivalled. Neither of these experienced observers appears to have had any difficulty in considering the salt-bearing rocks as true sediments and they

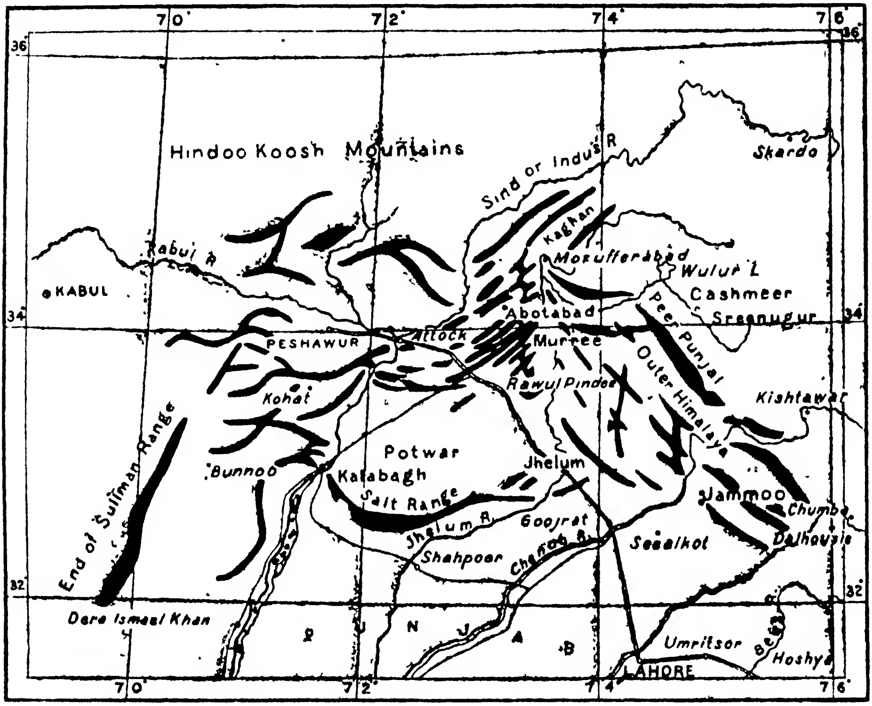


FIG. 1. *(After Wynne.)*

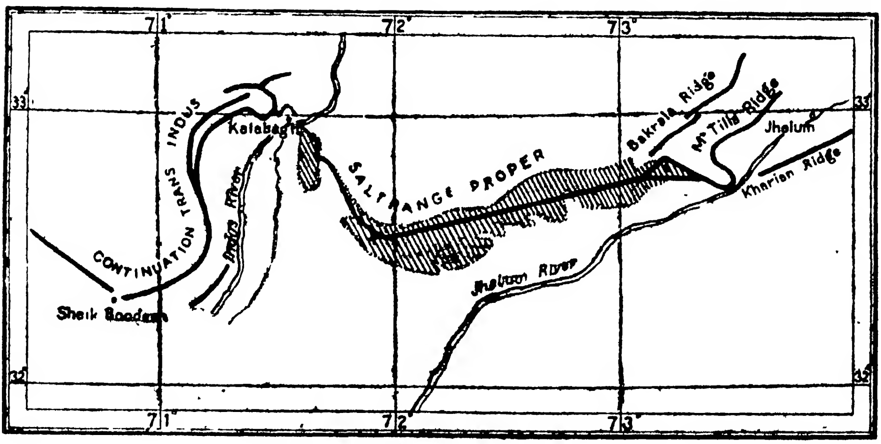


FIG. 2. *(After Wynne.)*

The sketch maps, figures 1 and 2 taken from Wynne's memoir, show very clearly the position of the Salt Range and its relations with the mountain systems on each side—the Himalayan arc to the east and the Baluchistan arc to the west. It is well established that these arcs are true mountain features, the mountains in each being due to compressive dynamic forces acting horizontally from the east-north-east and west-north-west on the Salt Range tract. The two above-mentioned arcs are in actual juxtaposition to the north of the Salt Range east of Abbotabad. The re-entrant bends at each end of the Salt Range in the east near Jhelum and in the west at Kalabagh show where the thrust from each side has been felt. The thrusts clearly follow an east to west rather than north to south axis so that any folding in the Range should be at right angles to this direction. The absence of such folding shows that little evidence of the thrusts will be found in the Salt Range for the simple reason that the forces of compression had been absorbed at the ends and was trifling in the middle. It is not to be forgotten that gneisses and other crystalline rocks occur in the Doabs only sixty miles south of the middle of the Salt Range. These rocks almost certainly form the platform on which the Salt Range strata rest, and this buttress of ancient metamorphic rocks together with its cover of Salt Range sedimentary formations appears to have resisted the thrusts from east to west.

felt justified, in ascribing a Palæozoic age to the Punjab Saline Series.[1] They seemed certain that the Kohat deposits were of a different age from those of the Salt Range, and considered the former provisionally as of Tertiary age.[2] These views were accepted by W. T. Blanford.[3] The occurrence of igneous rocks in the Saline Series was noted by Wynne.[4] Frequent emendations were made during the decade 1880-1890 to the geological succession of the Salt Range as first established by Wynne. His Olive Series of the eastern area could be correlated with the Speckled Sandstone of the western tracts, and the basal boulder bed in each case was found to be of glacial origin and the equivalent of the Talchir Boulder Bed of the Peninsula. No serious doubts were cast on the stratigraphical position of the Saline Series until C. S. Middlemiss produced important reasons for believing them to be of intrusive (igneous) origin[5]. He drew attention to the fact "that the Red marl must have possessed plasticity, and a power of movement, subsequent

[1] *Mem. Geol. Surv. India*, XIV, p. 83 and p. 73 respectively.

[2] *Mem. Geol. Surv. India*, XI, pt. 2, pp. 32-37 (136-141).

[3] Manual of the Geology of India, Part 2, (Calcutta, 1878), p. 488.

[4] *Mem. Geol. Surv. India*, XIV, p. 69, on which he gives the stratigraphical succession. This has since been changed by E. H. Pascoe, see *Mem. Geol. Surv. India*, XL, p. 337.

[5] *Rec. Geol. Surv. India*, XXIV, 1891, pp. 26-42, "Notes on the Geology of the Salt Range of the Punjab with a reconsidered theory of the origin of the Salt Marl." See also *Quart. Journ. Geol. Soc.*, vol. 9, 1853, p. 197. Letter to R. I. Murchison from A. Fleming.

to the deposition of many of the formations above it." This idea of an igneous origin, which received considerable support from T. H. Holland,[1] was accepted by R. D. Oldham[2]. It was then admitted that the salt might be younger than the strata with which it was associated. The idea of a Tertiary (Eocene) age for the Saline Series appears to have been first advanced by F. Koken and F. Noetling.[3] It carried with it the assumption that over-thrust faulting, advocated by T. H. Holland[4], must be invoked to account for the position of the Saline Series under older strata. Holland[5] also expressed the opinion that the Kohat salt must be of the same geological age as the Salt Range salt. In 1914, in a masterly paper, W. A. K. Christie[6] attacked the hypothesis of igneous origin. This authority on saline residues, after a careful study of the salt both at the Khewra mines and in the laboratory, clearly established the sedimentary character of the deposits of rock salt. Christie did not express his opinion with regard to the geological age of the Salt Range salt. In reading his paper, however, an impression is conveyed that he must have considered these beds (the Saline Series) to be, at Khewra, in a normal stratigraphical position and consequently the oldest strata seen in the Salt Range. He says :—

"The anomalous stratigraphical relationships existing between the Salt Marl and other formations of the Range may be explained as due largely to isostatic adjustment of the salt deposits, which the pressure of the superincumbent strata had rendered plastic. Taking a purely hypothetical example, a column of Purple Sandstone of specific gravity 2·29, 50 metres deep, succeeded by a column of Magnesian Sandstone of specific gravity 2·56 and the same cross section and depth, would be able to balance a column of rock-salt (assuming complete plasticity) of specific gravity 2·16 and similar cross section, 111 metres deep or would be able to thrust it 11 metres higher than its own surface. . . . Nor must we forget minor disturbances which one would expect to be caused in a rock with the properties possessed by the Salt Marl. When its more soluble matter had been removed by percolating waters, not only would the rock mass be less able to withstand pressure from any direction, but the more insoluble constituents would be left—as they now become after heavy rain—in the condition of a semi-fluid mud, plastic enough to be squeezed into almost any position."

[1] *Rec. Geol. Surv. India,* XXIV, 1892, p. 230, "Chemical and Physical Notes on Rocks from the Salt Range, Punjab."
[2] Manual of the Geology of India, 2nd Edn. (Calcutta, 1893), p. 112.
[3] *Gen. Rep., Geol. Surv. India,* for 1902-03, 1903, p. 26.
[4] *Imp. Gaz. of India,* vol. I, Chap. II, 1907, p. 22.
[5] *Ibid.,* p. 64.
[6] *Rec. Geol Surv. India,* XLIV, 1914, pp. 241-264, "Notes on the Salt Deposits of the Cis-Indus Salt Range."

Christie's investigations and conclusions have since been supported by Murray Stuart.[1] This geologist made a careful examination of a large number of salt exposures during an extended tour of the Salt Range, Kalabagh and the Kohat district. Stuart came to the conclusion that the Saline Series of the Salt Range (with its trans-Indus extension) and the salt-bearing strata of Kohat were of the same geological age. He considered that this age was Lower Cambrian or pre-Cambrian. He advanced the opinion that the laminated appearance and gneissic structure of the Kohat salt (as well as that of the Salt Range) were largely the result of foliation consequent upon thrust-faulting on a great scale. He, like Christie, drew attention to the plasticity of such a material as rock-salt and naturally concluded that the thrust-plane must be looked for in the Salt Marl and rock-salt horizon. Finally he thought he had produced evidence to show that he had found the zone of thrust-faulting. Stuart's admission of the possibility that the peculiar foliation, etc., which he saw might represent thrust-faulting really gave additional support to those who believed in a Tertiary age for the Saline Series. The controversy regarding the age of the salt deposits of the Punjab and Kohat was conspicuous for the paucity of the kind of data which could only lead to one conclusion and therefore not be used by either party.

This was the situation when, in 1920, E. H. Pascoe[2] summed up the available information and arrived at a conclusion which was undeniably fair at the time. He concluded that the Saline Series was regarded as of sedimentary origin in both regions, and that these deposits were likely to be of one geological age, which, from the evidence, he thought should be Tertiary (Eocene). He suggested (*op. cit.*, p. 363) that the Purple Sandstone, might be part of the Saline Series, representing the 'Red Clay Zone' of Kohat, and therefore, equivalent to the Lower Chharat stage[3] (middle Eocene). He upheld the idea of thrust-faulting to account for the anomalous position of the Saline Series (with the Purple Sandstone) below Cambrian strata in the Punjab. This summary became the official view

[1] *Rec. Geol. Surv. India*, L, pt. 1, 1919, pp. 57-97, "Suggestions regarding the Origin and History of the Rock Salt Deposits of the Punjab and Kohat."

[2] *Mem. Geol. Surv. India*, XL, pt. 3, 1920, pp. 337-371, "The Petroleum Occurrences of the Punjab and the North-West Frontier Province."

[3] In a recent paper, *Trans. Min. Geol. Inst., India*, vol. XX, pt. 3, 1926, pp. 210-215, L. M. Davies makes the Lower Chharat stage equivalent to the Laki stage which he considers must be Lower rather than Middle Eocene.

pending a re-survey and anyone unfamiliar with the ground, reading the whole story, could not help agreeing that the above summary correctly represented the situation. I fully believed and supported this view, but was aware that many sections required re-examination and that much of the structure could not be unravelled without a detailed re-survey of the Salt Range.

My duties in connection with the coal-fields of India took me to the Punjab Salt Range twice during the season 1926-27. As is well-known the more important coal occurrences lie along the southern edge of the plateau from Ara (N. N. W. of Baghanwala) through Dandot to Amb (N. N. W. of Warcha). My journeys crossed several localities in which important geological sections could be seen on the line of march. Thus in the cis-Indus region I was able to see two sections on my way to and from Ara, also the Jutana canon (Plate 2) and the Khewra glen (Plates 3 and 4). While at this locality I was deputed to report on a serious subsidence which had taken place in Khewra village—the result of the solution of rock-salt on the outcrop of which the village was situated (Plate 5). From Khewra I went to Dandot and its vicinity on two occasions for several days at a time (Plates 6, 7, 8, 9, 10, and 11—these photographs should be studied, in conjunction with the map, sheet 43 $\frac{D}{14}$ square C. 2). I also paid hurried visits to Chittidand on the west side of the Makrach gorge, to the Nilawan ravine (Plates 12, 13 and 14), and to the Warcha defile (Plate 15). I would like to draw particular attention to the photograph of the Warcha defile as I believe there occurs an outcrop of strata, flaggy beds and shales, which are older than the Saline Series. I was unable to give them, all the notice they deserve.

During the same field season (1926-27) I was obliged to examine the coal or lignite occurrences of Rajputana (Palana, in Bikanir), Baluchistan (Khost, the Sor Range and Mach), and the trans-Indus localities of the Punjab (Isa Khel and Kalabagh). It is well known now that the Tertiary coals of north-western India, including Jammu and Hazara which I did not visit, occur on the same geological horizon—the Laki stage (said to be middle to lower Eocene), probably included in the so-called Lower Chharat Stage. I journeyed to Kohat to investigate the reputed occurrence of coal near Shin Dand in the Jowaki tribal country and visited the salt deposits of Bahadur Khel and Jatta on my way from Bannu. (Plate 16).

II.—THE DANDOT SECTION.

In the course of my investigations in regard to the determination of coal reserves it was necessary for me to ascertain the geological structure of certain localities where a hidden coal-field might occur. By far the most interesting of such localities is the section seen on the hill slopes below Dandot. (See map, square C. 2, sheet No. 43 D/14). Here coal had been found at two places—one in a normal position under the Nummulitic limestone of the Dandot plateau at an elevation of 2,150 feet, and the other, quite abnormally, at the mouth of the glen (Uchli Kas) several hundred feet below (roughly on the 1,250-foot contour). The lower coal (of Kurlnia) has been worked in a small way for over 30 years. It is clearly the same seam as that of Dandot and as it occurs in association with Nummulitic limestone it had to be decided whether the structure was that of an overfold (anticlinal) or just that of a fallen mass which, in sinking into the plastic salt marls of the Saline Series, had turned over.

The peculiarities of this section south of Dandot had been noticed more than half a century earlier (in 1869-71) by Wynne[1], and about twenty years after (1891) by Middlemiss.[2] A. B. Wynne speaking of the section south of Dandot see figures 3 and 4 says (page 164):—

"The village of Dandot is perched upon the edge of lofty cliffs which overlook the plains and expose a fine section of the rocks (f. 25, Pl. XVIII); the arrangement, however, presented by this differs much from others in the neighbourhood,

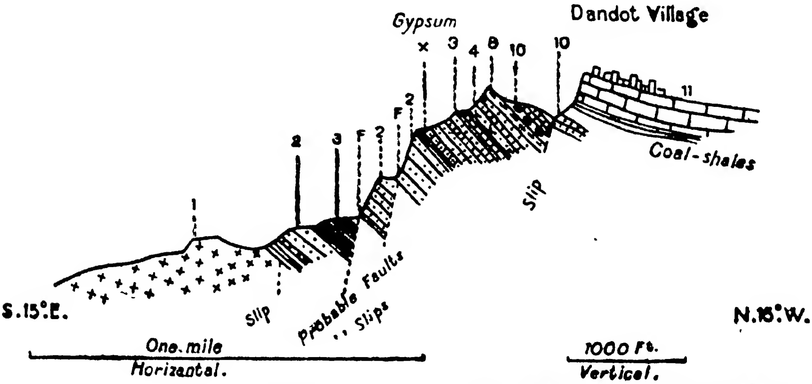


FIG. 3. (*After Wynne's* Fig. 25, Plate XVIII.)

[1] *Mem. Geol. Surv. India*, XIV, Art. 1, 1878, p. 164.
[2] *Rec. Geol. Surv. India*, XXIV, pt. 1, 1891, p. 33.

and in one respect, from all others of the range, namely, in the occurrence of a dark zone of sandy and shaly beds apparently near the base of the purple sandstone. This zone so exactly resembles the silurian[1] one above those rocks, as to afford reason for the supposition that it has been faulted into its present position, although the dip of the whole cliff section seems regular, and would indicate a sequence from top to bottom."

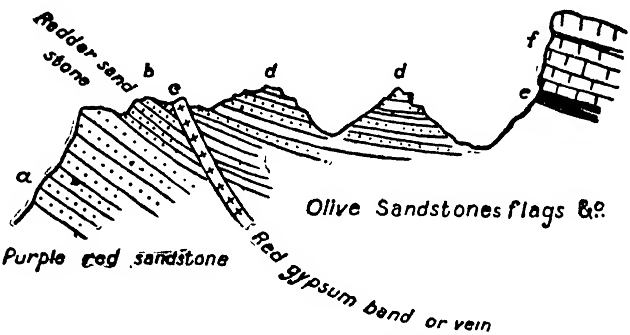


FIG. 4. (*After Wynne's* Fig. 26, Plate XVIII.)

Speaking of the same section, see figure 5, Middlemiss[2] says :—

" In Sketch Section No. 5, Plate III,[3] I have represented, in a more or less diagrammatic way, the inversion so prominent on the scarp south of Dandot. It will be seen from the section that the Purple Sandstone[4] is doubled in thickness with a core of gypsum and Red Marl.[5] The whole of the Boulder-bed and Olive series is also repeated in an inverted order and coming immediately below the Purple Sandstone.[6] The Magnesian Sandstone[7] and Salt-pseudomorph zone[8] have been omitted by some process of faulting. Then come the coal and associated beds in an outcrop overlying the nummulitic limestone with an inverted dip of 70°-80° northwards. In apparent order beneath this is a small thickness of soft sandstone, which may be Nahan Sandstone,[9] and next to this is a small amount of much shattered Purple Sandstone, and then the Red Marl forming the usual shapeless mounds.

This inversion of the Boulder-bed, Olive series, coal and Nummulitics was traced by me from a position immediately below Dandot for two miles in the direction of the Makrach valley. Along that line the Red Marl gradually approaches the

[1] *Neobolus* beds (Kussak stage).
[2] *Rec. Geol. Surv. India*, XXIV, pt. 1, 1891, p. 33.
[3] See Plate III and Fig. 5 of this page.
[4] Khewra stage.
[5] I could only detect traces of the Red Marl.
[6] Middlemiss has not noticed the *Obolus* or *Neobolus* beds (Kussak shale stage) which are clearly shown in my photographs, above and below the Purple Sandstone.
[7] Jutana (dolomite) stage.
[8] Baghanwala beds.
[9] This was of course a guess.

Nummulitics more and more. Owing to this it is scarcely likely that the Nummulitics with the coal bed could have their inversion resolved towards the south, before they become cut off by the invasion of the Red Marl.

Coal was being excavated from this inverted outcrop when I was last at Dandot; but the almost vertical lie of it will prevent deep working. Surface digging may, however, go on along the whole length of the inversion.

The axis of greatest flexure in the above section is of course in the Purple Sandstone, and as before remarked it is occupied by gypsum and traces of the Red Marl.[1] Again the greatest reversed fault is that separating the Red Marl (capped by a small amount of broken Purple Sandstone) from the Nummulitics."

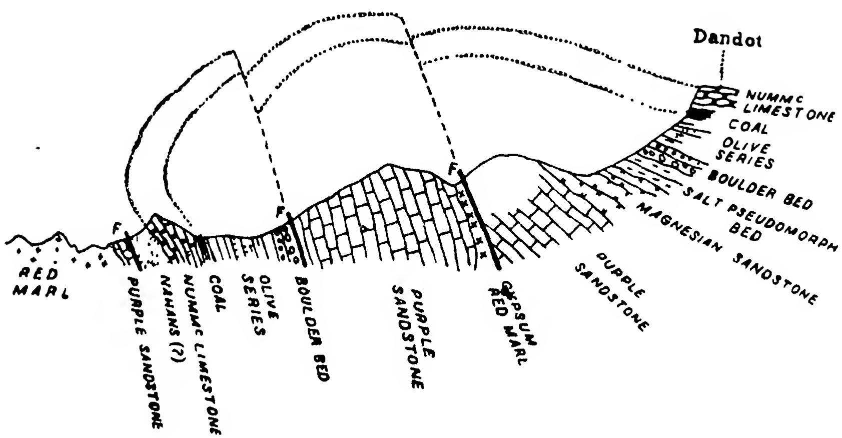


FIG. 5. (*After Middlemiss' Sketch section* No. V, Plate III.)

The conclusions arrived at by Wynne and Middlemiss for the Dandot section were different. This is seen by the sections drawn by them—Figures 25 and 26 (Plate XVIII) of Wynne's memoir and Sketch Section No. V (Plate III) from Middlemiss' paper.

Wynne does not include the lower coal (Kurlnia) and Nummulitic limestone in his Figure 25, and is a little sketchy in his location of the top of the Salt Pseudomorph beds. He has not interpreted the relationship of the gypsum band (Fig. 26)[2] with regard to the *underlying* beds quite correctly, and he does not show the Purple Sandstone and the Neobolus beds *above* the gypsum band. Middlemiss on the other hand has studiously included the Neobolus

[1] I could only detect *traces* of Red Marl, the gypsum is evident.

[2] Wynne's fig. 26 has been recently used as evidence by E. Parsons to support the idea of over-folding and thrust faulting and thus uphold the Tertiary age hypothesis of the Saline Series. (*Journ. Inst. Petrol. Tech.*, No. 58, Vol. 12, 1926, p. 481, "The Structure and Stratigraphy of the North-West Indian Oilfield".)

beds, both above and below the gypsum band, with the Purple Sandstone (Sketch section No. V). This is very significant as it indicates that he was convinced of the intimate conformable relationship of these beds. The above illustrations are reproduced below in figures 3, 4 and 5, which should be compared with the accompanying photographs Plates 6, 7, 8, 9, 10 and 11. Plates 8 and 9 were taken from hill "2061" due south of the Inspection bungalow at Dandot. The view, looking east-north-eastward, corresponds to Wynne's figure 25 and Middlemiss' Sketch section, No. V. In Plate 9 attention is directed to a large mass of Cambrian strata which has sunk bodily into the bright red marl of the Saline Series.[1] The fact that this great subsidence is on the strike of the Cambrian beds seen in these photographs becomes more significant when the presence of the "sink-hole" in the Uchli Kas (Plate 8) is noticed. Plate 10 from the top of No. 3 incline (Dandot) looking east by south towards Khewra, gives a better view of the sunken mass mentioned above. The sunken mass is largely composed of Neobolus Shales capped with the Jutana Dolomite (Magnesian Sandstone) and underlain by Purple Sandstone. The Salt Marl, which forms a continuous belt eastward into the Khewra glen, overlooks the top of the sunken mass. The amount of subsidence, gauging from the Cambrian beds seen in the cliffs on the left of the picture (Plate 10), is probably 600 to 700 feet.

Plate 11 was taken from a small spur just below the summit of hill "2340"[2] looking westward over the Uchli Kas to hill "2061". This view corresponds with that given in figure 26 by Wynne. The gypsum band is seen to be quite conformable to the underlying beds (Purple Shales and Sandstones). Unfortunately the picture is not clear enough to show the Neobolus beds above the Purple Sandstone which lies on the gypsum band. Again attention is drawn to the behaviour of this feature on a continuation of its line of strike westwards. The inverted beds are entirely absent evidently due to their superficial nature and the depth to which erosion has removed the strata. The normal strata on the other hand are seen at the exit of the Makrach gorge, where the Saline Series occurs as usual at the base of the scarp and underlying all other beds.

[1] The exact location is N. W. of hill "1317" above the words 'Salt Chauki' in map square C. 2; Sheet 43 D/14: 32° 39′: 72° 59′ 20″.

[2] It is marked as "1340" on Sheet 43 D/14 which is wrong.

The sequence of strata in the scarps below Dandot (map; square C. 2, Sheet No. 43 D/14) is as follows:—

	Beds	Stage	Age
	Soil and tufa		**Recent**
	Nummulitic Limestone	(Kirthar stage)	Middle to upper Eocene.
Wynne's Olive Series.	Coal-bearing shales	(Laki stage)	Lower to middle Eocene.
	Speckled sandstones	(? Barakar stage)	Lower Permian to Upper Carboniferous.
	Conularia bed (Pidh)		
	Bivalve horizon (Pidh)		
	Glacial Boulder bed	(Talchir stage)	Upper Carboniferous.
	Salt Pseudomorph beds	(Baghanwala stage)	Upper Cambrian.
	Magnesian Sandstone	(Jutana (Dolomite) series)	Middle to lower Cambrian.
	Neobolus Beds	(Kussak (shales) stage)	
	Purple Sandstone and Shales.	(Khewra stage)	Lower Cambrian.
	Gypsum bed	Saline Series.	
	Salt Marl with Khewra trap		
	Rock salt.		
	Gypsum bed		

Plates 8 and 9, show tolerably well the "inversion" of the beds below Dandot. In many ways it is a remarkable inversion. There is no sign of any curving or arching in the bedding of the strata and on the line of strike or axis of the inversion there is no continuity of the feature. To the west the beds have been entirely removed at the mouth of the Makrach gorge. To the east only bright red saline marls (Salt Marl) are seen beyond the Dandot ravine. These marls pass over the ridge into the Khewra glen and are shown in Plate 4. In this view, taken looking westward, *i.e.*, in the direction of Dandot from Khewra, there is evidence of an over-fold in the Salt Marl. The explanation for the over-fold in the Salt Marl at Khewra is not in any way connected with a tectonic over-fold; it is entirely due to the squeezing out of the plastic salt marls in the manner described by Christie. The diagrammatic representation of the structure of the over-fold at Khewra is seen in figure 6 (A, B and C). It is seen from these sketches that the whole phenomenon is entirely explained by the removal of soluble matter from beds at the base of a scarp, the sliding outward of the overlying beds, and the upheaval of the underlying plastic soluble beds as a result of the weight of the main scarp. The beds of rock-salt outcrop in the Khewra glen. One exposure is seen due west of the village. The village is itself situated on the débris of the Salt Marl which obscures a thick bed of rock-salt below. This solid salt has been subjected to solution by percolating water from the glen, and as a result a large cavity formed under the village. The overlying marl and a considerable part of Khewra village sank

20 feet when this cavity collapsed just before my visit. (See Plates 3 and 5.) At the time of my visit the little spring which was the main cause of the subsidence was still removing salt in solution at the rate of 15 lbs. a second. This totals 160,000 tons of salt or 2,600,000 cubic feet of solid matter in a year—the work of 0·75 cusecs of water. The annual output of the Mayo mines at Khewra average roughly 100,000 tons of salt, so that more salt was being removed in solution than by actual mining at the time. The remedial measures have of course stopped this. When we realise that rock-salt is 27,000 times more soluble than limestone, and remember that the Saline Series along the foot of the Salt Range scarp averages 1,000 feet, we begin to realise the scale on which the processes of solution are operating, and can gauge the importance of the results likely to be caused by subsidence and isostatic balance. The peculiar and numerous areas of disturbed strata, *e.g.*, slips, swallow-holes, sunken masses are all, in my opinion explained—not only at Khewra, or Warcha but also on both sides of the Indus at Mari and at Kalabagh. Is it then absurd to look for a similar explanation for the section below Dandot ?

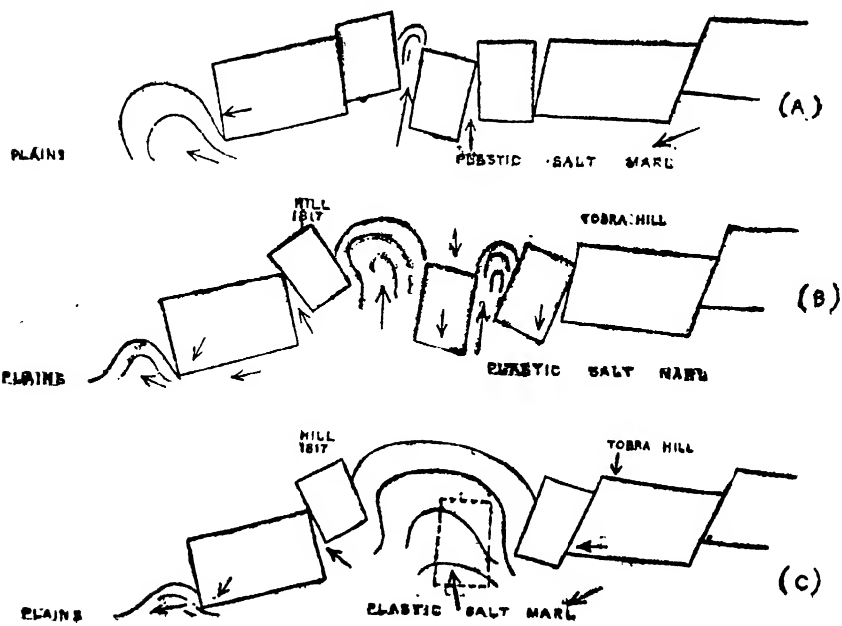


FIG. 6.

The sections shown in Figures 6 and 7 lie across a line from Hill "2061" along the gypsum band of the inverted beds below Hill "2340" (Plate 8), through the sunken mass on the east side of the Dandot valley (Plate 10) and on to the Khewra glen (Plate 4).

The sketch sections of figure 6 are intended as an explanation of the overfolded condition of the Salt Marl on the west side of the Khewra glen. (A) shows the first stage of a plateau breaking up. It consists of hard bedded horizontal strata lying on a plastic layer. This plastic material (the Salt Marl) can escape along the foot of the plateau scarp. This it does and the overlying beds fracture with bending. The plastic material can now escape upwards through the cracks as these fissures widen with the outward movement of the broken masses towards the plains. Some of the masses will sink

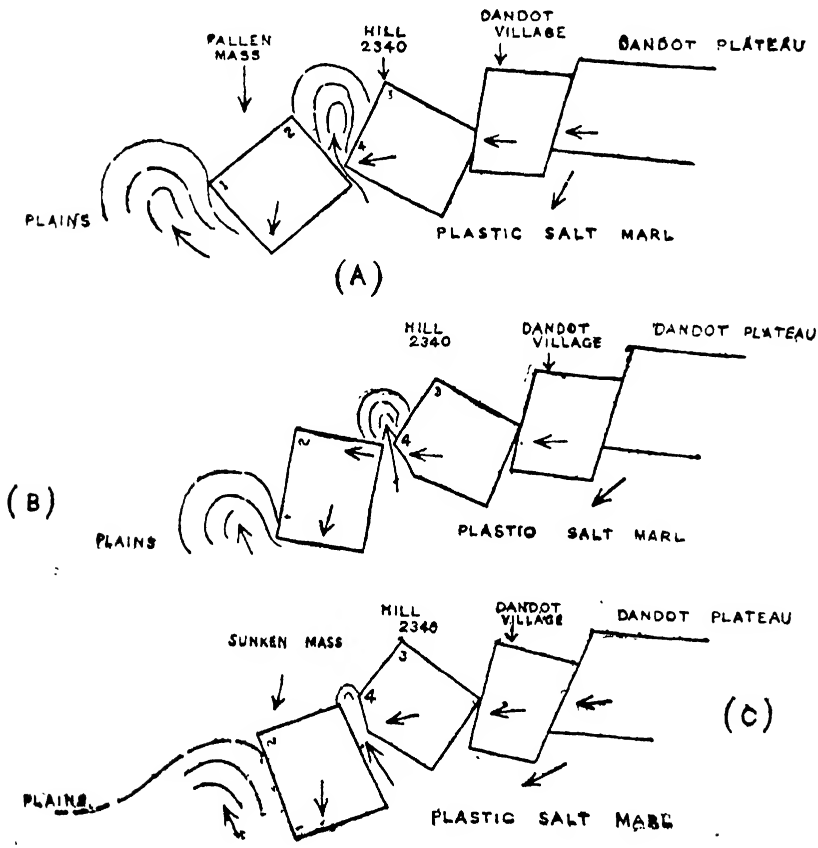


FIG. 7.

into the marl, others will become tilted. If the plastic material be very soluble it is quite impossible to guess the extent to which the strata will be dislocated and finally settle. Overturning cannot be unreasonable under such conditions.

It is not to be forgotten that the drainage of the Pidh valley is enclosed and after disappearing emerges as springs in the Khewra glen. The subsidence in Khewra village, the sunken mass south-east of Dandot, and the sink-hole of the Uchli Kas, all on the same line of strike and evidently related with the plastic Salt Marl and its associated soluble rock-salt beds, are very suggestive. The inverted beds in figure 7 are easily explained on this isostatic hypothesis which was advanced by Christie several years ago.

In my opinion the explanation of the inversion of the beds is depicted in figure 7. In a sense it is an over-fold but there is no corresponding synclinal from which the coal horizon can be expected to crop out once more, and this time nearer to the plains. It seems to me a great strip of massive strata has rolled over instead of slipping down or sinking in. This detached mass has been assisted in overturning by an out-flow of plastic Salt Marl above it. The main scarp has sunk forward and jammed against the fallen mass and with subsequent solution and settling the beds have come to occupy the curious position they do. The following extract taken from "A Manual of the Geology of India", Part II: Extra-Peninsular Area, 1878, page 487, is of considerable interest in this connection:—

"Owing to the softness of the marl, and to the tendency of harder rocks to slip upon it whenever it is sufficiently saturated with water, to destroy its coherence, and also to the salt beds being dissolved by water the rocks of the Salt Range are broken and mixed up in the most complicated manner, masses of the marl having been squeezed by pressure in places into a position in which they appear to overlie more recent rocks, whilst all the newer formations are cracked and faulted. The detailed geology of the range is consequently very intricate, and it is not always easy to tell whether dislocations of the strata are due to true faults traversing all the beds, inclusive of the salt marl, or whether the displacement is merely due to complicated landslips."

III.—SUPPOSED EOCENE AGE OF THE SALINE SERIES.

If there is one horizon better than another for correlation purposes among the Tertiary strata of north-western India it is the coal-bearing pyritiferous shales which comprise the Laki stage. This Laki stage is said to represent a middle to lower Eocene age in Sind, Baluchistan, the Punjab and Rajputana. It is represented

in the North-West Frontier Province by the Lower Chharat stage.[1] The Tertiary coal seams of Baluchistan, the Punjab, Rajputana, Jammu and Hazara (North-West Frontier Province) are believed to represent the Laki stage in these several areas. The presence of marine fossils in the shales, both above and below the coal seams, indicate lagoons and coastal marshlands when these deposits were being formed. Below the coal-bearing Laki stage a laterite bed has been recognised in various places—Sind, Rajputana, Jammu, and in the Salt Range. This laterite horizon exactly corresponds with a similar bed in Surat (Bombay Presidency), and is thought to mark a stratigraphical 'break' between the Upper Cretaceous period and earliest Eocene times. The presence of laterite is indicative of land conditions during an interval when a dry and wet monsoon climate prevailed. Above the Laki coal-bearing stage lies the Nummulitic Limestone of the Kirthar stage, which is thought to be middle to upper Eocene in age. These limestones are believed to have been deposited in the clear waters of a shallow sea. From the geological history of the above strata it is seen there is no evidence of deserts, aridity or any period of desiccation. It is thus evident that the climatic and geographical conditions prevailing in north-western India during Eocene times, within the limits of the area under consideration, were not suitable for the accumulation of salt deposits at all comparable with those of the Saline series of the Salt Range.

In connection with the coal or lignite and the petroleum occurrences in the Tertiary strata of India E. H. Pascoe[2] has made some observations of considerable importance. He says:—

"The association of coal or lignite with ordinary free petroleum is widespread and scarcely requires recapitulation. . . (p. 232).

Speaking of certain anticlines in Burma he remarks: "There is a distinct gradation from lignite to oil-bearing beds corresponding to one from shallow to deep-water conditions . . . . ." (p. 235).

Speaking generally he says: "We are led to conclude that, in places where such an association can be recognised, they [coal and petroleum were probably derived from not dissimilar sources, under different but comparable conditions. Where conditions were eminently favourable for the formation of coal, they apparently were not so for petroleum, since beds bearing thick seams of coal are apt

[1] L. M. Davies, *Trans. Min. Geol. Inst. India*, XX, 1926, p. 215. See also E. S. Pinfold, vol. XLIX, p. 144. Also, W. L. F. Nuttal, *Q. J. G. S.*, LXXXI, 1926, pp. 417-452.

[2] *Mem. Geol. Surv. India*, XL, 1912, p. 232.

to contain little or no petroleum; on the other hand, where conditions did not permit of more than thin layers and local patches of lignite or coal being formed, larger quantities of oil are liable to be found—one is tempted to say 'instead of coal'." (Page 237.)

Pascoe's conclusions have the weight of very extensive field observations—including N. W. India, Assam and Burma. In the Assam region the association of coal and oil is too obvious to escape attention and has been repeatedly remarked upon.[1] The depth of water in which the vegetable matter accumulated is evidently one factor—shallow water for coal and deeper water for oil. Now the workable coals of Tertiary age—in other words the shallow water deposits of the Laki stage—occur (*a*) in the Harnai-Quetta-Bolan area of Baluchistan, (*b*) in the Isa Khel and southern Salt Range belts of the Punjab, (*c*) in the Palana tract of Bikanir (Rajputana), (*d*) in the Jammu region of the Himalaya, and (*e*) in the Dore ravine of Hazara. In the intervening areas, *i.e.* (1) between the Salt Range and Quetta, and (2) between the Salt Range and the Himalaya, petroleum occurrences are more frequent than in the coal-bearing areas mentioned. These petroleum seepages, etc., in all probability represent the continuation of the Laki stage, *i.e.*, a deeper water representative of it, under the younger strata of the intervening areas (1) and (2). In this way we may conclude that the petroleum-impregnated bituminous salt deposits of Kohat[2] indicate the presence of the Laki stage.

The association of bituminous matter with the rock-salt of the Kohat area, in addition of course to the chief fact that the rock-salt occurs as the oldest strata in the sharply folded anticlinals under beds of middle to upper Eocene age, is partly responsible for the belief in a Tertiary age for the salt. Pascoe,[3] in his tentative summary of the available information, says of the Kohat area:—" ....the salt must be referred either to the lowest horizons of the Lower Chharat or must represent the Lower Nummulitic. Of the two alternatives the former seems the more likely ...." and, he continues (p. 366) " If we are to assign the same age to the salt

[1] F. Mallet, *Mem. Geol. Surv. India*, XII, 1876, p. 356.

[2] E. H. Pascoe, *Mem. Geol. Surv. India*, XL, 1920, p. 417. In this connection also see F. W. Clark, *W. S. Geol. Surv.*, Bull. 595, 1920, p. 741. There is not the slightest doubt that the opinion so briefly advanced by Pascoe must be correct for the Tertiary coal and oil-fields of India. A detailed study of these may give a solution to the vexed problem of the mode of formation of coal.

[3] *Mem. Geol. Surv. India*, XL, 1920, pp. 365 and 366.

and gypsum of the Salt Range, we must suppose the older rocks to have been thrust over them." Remembering that L. M. Davies[1] considers that the Lower Chharat is the equivalent of the Laki stage—we are confronted with the problem of finding room for the Saline Series in association with the coal horizon (Laki stage) of the Salt Range. It is true that the basal beds of the Salt Range coal-bearing Laki stage are not clearly seen. It is, however, certain that there cannot be more than 100 feet of strata between the coal horizon and the underlying beds of Mesozoic (possibly Palæozoic) age. The Saline Series is over 1,000 feet thick and is never seen in juxtaposition with the Laki stage. If figure 5[2] is studied it will be seen that the Salt Marl is not even seen in contact with the inverted mass of Nummulitic Limestone in the Kurlnia coal locality. The Salt Marl is always intimately associated with the Purple Sandstone in this section. If thrust planes are invoked, either at the base of the Laki coal-bearing stage or above the Purple Sandstone, these thrust planes will have to be considered as having become involved in the folding or inversion of the beds below Dandot as seen in figure 5. I can see no evidence to support either view. Plates 8 and 9 show the Purple Sandstone to be conformably overlaid by the Neobolus (shales) Beds, and as already stated the Salt Marl never appears on the coal-bearing (Laki stage) horizon throughout the Salt Range. The obvious conclusion, from the facts presented by the Salt Range sections, is that the Saline Series is not of Tertiary age and appears to be older than the Purple Sandstone. Also since the Tertiary age hypothesis for the Saline Series of the Salt Range originated from conclusions made in regard to sections in the Kohat region it would appear logical to conclude that these Kohat sections have been wrongly interpreted and require careful re-examination.

On my way from Bannu to Kohat, in search of a supposed coal-bearing horizon (Laki stage) at Shin Dand in the Jowaki tribal area, I visited the salt occurrences of Bahadur Khel and Jatta. The section at Bahadur Khel has been studied by Davies[3]. I cannot see how this observer, from the facts he discloses, can be satisfied that the rock-salt forms part of the Eocene strata which lie above it. At Jatta I disagree with the interpretation of a conformable

[1] *Trans. Min. Geol. Inst. India*, 1926, p. 215.
[2] Middlemiss' Sketch Section, No. V, of the beds below Dandot. Figure 5 above in text.
[3] *Journ. Asiat. Soc. Bengal* (New Series), XX, 1924, pp. 207-224.

series of beds which include the salt with the overlying Tertiary. All the evidence I was able to collect at Jatta merely pointed to the salt being older than all undoubted Tertiary strata. The age of the salt-bearing beds at Jatta could, in my opinion, with equal honesty be referred to any age—Mesozoic or Palæozoic—below the Lower Chharat (Laki) stage. I was impressed with the intensely folded condition of the Tertiary strata throughout my traverse from Bannu to Kohat. I crossed the line of strike of the beds on my journey so that the same horizons were repeatedly seen. The view of tightly folded strata in succeeding changes and reversals of dip and alternating troughs and anticlinals almost became tiresome. The salt always crops out in the greatest anticlinals. These are naturally the various salt localities of the Kohat district. Davies[1] has shown that beds related to the Laki stage are curiously associated with the Bahadur Khel salt, and I feel convinced that the presence of bitumen and the smell of petroleum in the salt indicates the existence of the Laki stage. The question is how is it related to the salt here when it is not associated with the Salt Marl of the Salt Range?

Christie's explanation for the anomalous position of the Salt Marl of the Salt Range is equally applicable here. Remembering the greatly folded condition of the Tertiary strata in the Kohat region and the fact that a material of the nature and consistency of rock-salt must become plastic under severe compression it is almost certain that such a substance, if present in abundance, even at a considerable depth, would tend to be squeezed out upward in the manner of an igneous intrusion. An anticline, particularly a faulted anticline, would be just the place to expect the extruded material to occur. Most of the anticlinals where the Kohat salt occurrences lie are faulted. That the salt has been subjected to intense compression is evident from its schistose structure. At a distance of a few yards lumps of the rock-salt look exactly like a heap of grey gneiss. If the bituminous matter associated with the Jatta and other Kohat salt indicates the presence of an original Laki (deeper water) stage, then the compressional effect of the folding will account for the absence of this horizon now. The plastic rock-salt would be squeezed upwards into the anticlines by the intense folding, which would cause the coaly

[1] *Journ. Asiat. Soc. Bengal*, (New Series), XX, 1924, p. 220.

(or oily) shales (Laki stage), below the Nummulitic Limestone (Kirthar stage) to become attenuated and to be forced into the salt with an induced marginal parallelism between the fragments and the foliation of the salt. The absence of any older strata in the anticline does not necessarily affect the age of the salt. It can be of any age older than the Laki stage and can therefore be the equivalent of the Saline Series of the Salt Range, *i.e.*, Lower Cambrian or pre-Cambrian.

I have tried to shew that it is not possible to account for a great period of salt deposition in the Salt Range and Kohat regions during the early Eocene period. It seems to me impossible to correlate the Kohat salt with the Saline Series on any Tertiary age hypothesis, because the Saline Series cannot be fitted into the Laki stage by any evidence nor by any reasonable argument. All the evidence, in my opinion, points to a Lower Cambrian or pre-Cambrian age for the Saline Series—these strata are lying in a normal way beneath the Purple Sandstone in the Salt Range. It is far simpler to regard the Kohat salt as pre-Laki in age and as squeezed up in to its present position during the period of late Tertiary folding. For those who insist on a correlation of the Kohat salt with that of the Salt Range it is permissible to regard them both as Lower Cambrian. There is always the possibility that, although both salt deposits are probably Palæozoic in age, the Kohat salt may be younger than the Salt Range material. It may represent re-deposited salt from the erosion of the Salt Range salt, *e.g.*, in Salt Pseudomorph stage times, while the arid conditions of the Cambrian era still persisted. This, however, is quite fanciful and is advanced largely to account for certain chemical differences in the salts of Kohat and Khewra as observed by H. Warth.[1] These differences it appears could be equally accounted for by the severe treatment the Kohat salt has received during the folding movements and by the presence of the bituminous matter.

IV.—ARGUMENTS IN FAVOUR OF A CAMBRIAN AGE FOR THE SALINE SERIES.

Table I shows the strata immediately above and below the Cambrian beds of the Salt Range.

[1] *Mem. Geol. Surv. India*, XI, 1875, pp. 26-27.

TABLE I.[1]

7. Speckled Sandstone of Pidh Conularia beds Bivalve horizon	Permian.
6. Glacial Boulder Bed	Upper Carboniferous.
——————Great unconformity——————	
5. Salt Pseudomorph Beds (Baghanwala stage of Noetling) 4. Magnesian Sandstone (Jutana Dolomite stage of Noetling)	Upper Cambrian.
3. Neobolus Beds Wynne's Silurian Middlemiss' Obolus beds and Noetling's Kusak shale stage. 2. Purple Sandstone and Shales Noetling's Khewra stage	Middle Cambrian.
——————peculiar junction; see Sketch Sections III and IV, Plate III (*Rec. Geol. Surv. India*, XXIV, 1891, by C. S. Middlemiss.)	
1. Saline Series: Salt Marl with igneous rock. Gypsum and dolomite. Rock Salt.	

As a rule the Purple Sandstone is always associated with the Salt Marl, and in clear sections conformably related with the Neobolus beds. The finest section of the Cambrian strata, seen in the Salt Range, is that of the Jutana cañon. The beds are clearly a conformable series as seen in Plate 2. A conformable relationship is also evident from Plate 9 taken of the same strata in the Nilawan ravine. In both these views the beds are seen to be undisturbed. Plates 8 and 9 of the slopes below Dandot still show the parallelism of the Cambrian strata even in their tilted and inverted position. The absence of any stratification in the Salt Range sections where the Salt Marl is exposed makes it impossible to say whether the Saline Series is conformable with the overlying Cambrian strata. In many sections (see Middlemiss' Sketch Sections III and IV, Plate III)[2] the basal shales and flaggy

[1] Compare with Succession given by Wynne on p. 69, *Mem. Geol. Surv. India.* XIV, 1878, and sequence by Pascoe on p. 337, *Mem. Geol. Surv. India*, XL, 1914.
[2] *Rec. Geol. Surv. India*, XXIV, 1891.

beds of the Purple Sandstone appear to have sunk into the marl. The occurrence of nodules and boulder-like masses of igneous material[1] further complicates the question. However, if the Salt Marl represents, as suggested by Christie, a residual clay[2] from which a considerable amount of soluble material has been removed, it is quite possible that in deep, unaltered sections the Saline Series may pass upward in perfect conformity into the basal shales of the Purple Sandstone.

I have previously drawn attention to the greatly folded condition of the Tertiary and other strata of the Kohat region. There is little doubt that the further we go to the north-west from the Indus at Kalabagh the more noticeable the folding[3] becomes. The folding is close at Jatta and thrust-faulting is common in the Kohat area, but the beds in the hills between Kohat and Peshawar are yet more intensely folded, while thrust-faulting and overfolding in the Khyber defiles are exceedingly complex. In contrast with the folded strata of the Kohat area the Salt Range beds are almost undisturbed by dynamic forces. I cannot do better than quote Middlemiss[4] in this connection. He says:—

"Where else in India, or in the world perhaps, can each formation be followed by the eye in its broader lines by its colour, over hill and hollow, over plateau and ravine, when the range is viewed on a clear day from some commanding height? Where else can be seen a body of horizontal strata comprising members of the Palæozoic, Mesozoic, and Cainozoic groups, lying one above the other in a single cliff section, and apparently as unbroken by great unconformabilities, or by volcanic intrusions, as if they had just been formed? Where else does the geological record, from Cambrian times upwards, present us with a set of rocks unaltered by metamorphism, undisfigured by chemical or dynamical changes, as free in fact from the dust of time as an uncut volume fresh from the binder's hands?"

And this is the impression conveyed to my mind by such views as the Jutana cañon (Plate 2) and others. Even the remarkable section below Dandot gives the same impression, once the significance of Christie's explanation is fully appreciated, for as Middlemiss on a further page (41) also says:—

"The Purple Sandstone is totally devoid of metamorphism in the strict sense of the word. What is true of the lowest rock-group in this respect is of course

[1] The Khewra and Nilawan trap appears to represent an altered basic igneous rock—probably a contemporaneous lava flow. No analysis has been made as the rock is so deeply altered that little reliance could be placed on its present composition.

[2] *Rec. Geol. Surv. India*, XLIV, 1914, p. 261.

[3] The beds are folded into arches and synclinals as distinct from broken, tilted, but un-curved strata.

[4] *Rec. Geol. Surv. India*, XXIV, 1891, p. 19.

true of all the succeeding younger formations. In addition to the absence of any metamorphic strata in the range, there is also wanting everything in the nature of a slate series—there is not a slate in the whole country."

The above extracts are not intended to obscure the fact that there are exposures showing undoubted evidence of tectonic forces—however localized these may be to a single formation, *viz.*, that of the Salt Marl. Wynne[1] has drawn attention to the disturbed condition of the Salt Marl in various places. The peculiar over-folded condition of the Salt Marl from the Khewra glen seen in Plate 4 is an excellent example. Further cases are seen elsewhere, *e.g.*. the Nilawan ravine (Plate 12) and the curious exposures (Plate 15) in the Warcha defile above the mines. An explanation, which is entirely in agreement with my field observations, has been supplied by Christie for all such exposures. He pointed out the plastic consistency and yielding nature of the Salt Marl and stated that it would become like fluid mud when wet. I have utilized these ideas in figures 6 and 7 to explain the structure of the sections seen in Plate 4 and to elucidate the section of inverted strata below Dandot (Plate 8). In studying these photographs and sketch sections (as I have drawn them) it should be clearly remembered that the tilted strata overlying the Salt Marl are only seen actually along cliff margins when the Saline Series are exposed in the ravine (or foot of the scarp) below. There is no better place for studying this phenomenon of isostatic subsidence and tilting of the Cambrian strata of the Salt Range than the Khewra-Dandot area. (Map sheets 43. D./14 and 43. H./2.)

Taking the Khewra section first, *i.e.*, Plate 4 of which figure 6 is the key, hill "1817" which overlooks Khewra Railway Station from the north-west, it consists of a basement of Salt Marl (only seen from the plains), upon which rest in order the Purple Sandstone, the Neobolus beds and a capping of massive Magnesian Sandstone. The strata dip gently towards the plains, *i.e.*, to the south. The beds making the final pile of the hill ("1817") are tilted more sharply as shown in figure 6. In the saddle to the north of hill "1817" the Salt Marl is seen at a higher level and occupies a wide strip of the spur running southward from Tobra hill. In the cliffs below Tobra village the Purple Sandstone, Neobolus beds and Magnesian Sandstone are seen with northerly dips. The summit of Tobra hill

[1] *Mem. Geol. Surv. India*, XIV, 1878, pp. 150 and 164, etc.

contains the Salt Pseudomorph beds with a capping of the Glacial Boulder bed and the overlying Speckled Sandstones. With regard to the mass of hill "1817" it might at first sight appear that the Cambrian strata there were let down by faulting. In a sense this is true, but taken in conjunction with the over-folded anticlinal structure seen in the Salt Marl and the northerly dip of the Cambrian strata in the main scarp (Tobra hill) I think it will be admitted that the diagrammatic representations I have made in figure 6 gives a tolerable explanation of what has happened.

In my account of the Dandot section (see Fig. 7) an explanation on the same lines is given for the structure there found. I am aware that in the section the evidence favours sinking and a turning over of the detached Cambrian beds, whereas the Khewra section, from Tobra Hill to hill "1817" is suggestive of upheaval. It is an upheaval of the Salt Marl and a sliding forward of the Cambrian strata towards the plains. Seeing that both sections are on the same line of strike it would add considerably to my arguments if evidence of subsidence or sinking of the overlying beds—the Cambrian strata—could be found in close association with the Khewra section. This actually occurs in two cases—(1) the subsidence in Khewra village and (2) the other, larger subsidence, is seen on the Dandot side of this section as illustrated by the sunken mass in Plate 10 and shown in its correct line of strike in Plate 9. The dislocations shown in figures 6 and 7 and the subsequent tilting, sliding forward, sinking in and turning over have, of course, taken place gradually over a considerable period of time (Recent time) during which erosion and solution of the Salt Marl have also been in progress. The weight of the massive bedded rocks on the Salt Marl, the yielding and upheaval of the plastic Salt Marl and the resulting confusion are, however, clearly explicable on Christie's hypothesis.[1]

In this connection the following extract from Pilgrim's section[2] on the Hormuz salt is of considerable interest. On page 47 he says:—

"The structure of the Anguru inlier of the Hormuz is even more abnormal.. I failed to detect any appreciable movement in any other series than the Hormuz,

[1] There is no doubt that thrust-faulting can be advanced but I fail to discover what purpose it could serve in accounting for the confusion of the sections. No thrust plane can occur outside the zone of the Salt Marl and if such faulting does occur in this horizon it has been involved in the dislocations which have affected the Cambrian strata. From what has been said on an earlier page it is my definite opinion, that no system of thrust-faulting can make the Saline series Lower Eocene in age. Why then have any thrust plane at all, seeing that there is no evidence for such a suggestion;

[2] *Mem. Geol. Surv. India*, XLVIII, pt. 2, 1925, p. 47.

and in the case of this the only formation which seems to have moved is the salt. It has carried with it, no doubt, portions of the overlying dolomitic limestones and volcanic tuffs, but here as elsewhere these only exist in a fragmentary condition in the red gypsiferous earth which is mingled with the salt in places. That the salt has moved is certain as we find it overlying each one of the Tertiary sedimentary series in turn, Eocene limestone and shales, Oligocene beds, and Fars, and forming the upper portion of the hill mass, while the steeply dipping Tertiary beds are exposed in the gorges. . . . . . At Anguru . . . there was evidently a great mass of superincumbent strata on the salt when the earth pressures began to operate. The salt folded immediately, as in the previous case and the superincumbent strata fractured, no doubt very gradually at first. . As bed after bed fractured, the salt found its way up by the outlet so offered until equilibrium was restored. . ."

It is interesting to compare the Salt Range Saline Series and Khewra stage with the Hormuz series of Persia. Pilgrim[1] gives the following succession :—

The Hormuz Series:

4. Purple Sandstone; grits and shales up to a maximum of 500 feet. A considerable portion of the purple sandstone seems to be saliferous in some sections, as in the gorge of the Tangi Zagh, judging by the salt which crystallizes out on the surface of the rock.

3. Volcanic beds, rhyolites, gypsiferous tuffs, etc., up to 200 feet thick. There appear to be no other igneous rocks in the area than those of the Hormuz series, and certainly none younger in the Hippurite limestones or the Eocene.

2. Dolomitic Limestones and shales. From 60 to 300 feet thick. The shales are often black and fetid or yellow, fissile and thin bedded, occasionally with rhyolites.

1. Rock-Salt. A bedded deposit up to 1000 feet thick and less. It is never found except in association with the other members of the series, which must therefore be taken as a single unit.

Since Pilgrim's memoir was published trilobites are said to have been found in association with the salt beds of the Hormuz series. Dr. Murray Stuart notes that [2] :—

"The Discovery by Dr. H. de Bockh and the geologists of the Anglo-Persian Oil Company of Trilobites in the strata associated with the salt of the Persian Gulf area more or less establishes the early Cambrian or Pre-Cambrian age of the salt of North-West India. Dr. de Bockh and his colleagues conclude that :—

There are, therefore, only two possibilities for the age of the Hormuz salt —

1. The sequence in the Hormuz inliers is normal, and the salt is of Pre-Cambrian or more probably of Cambrian age.

[1] *Mem. Geol. Surv. India,* XLVIII, pt. 2, 1925, p. 14.
[2] The Geology of Oil, Oil-Shale, and Coal, 1926, p. 86.

2. The rocks now overlying the salt form the remains of a nappe which must be older than middle Cretaceous. There is no proof that nappe structures were formed in this part of the Tethys in Triassic, Jurassic, or Lower Cretaceous times. If there is a nappe covering the salt it must be of palæozoic age which means that the salt can not be younger than Palæozoic.

The foregoing observations and conclusions must be considered when the problems of the Saline Series and the Cambrian of the Salt Range are studied."

If these observations have been confirmed there will be no point in further discussing the Tertiary age hypothesis of the Kohat and Salt Range salt. These discoveries by the geologists of the Anglo-Persian Oil Co. may indicate the extension of the Hormuz series under the newer rocks of the intervening areas of Eastern Persia and Baluchistan to the Salt Range. Such an extension is not as absurd as it may at first appear. Recently, the fossils found many years ago by H. C. Jones near Neemuch have been accepted by the late Charles D. Walcott and other eminent American palæontologists as recalling the brachiopod *Acrothele* which has Lower Cambrian affinities.[1] There are thus grounds for believing that the Cambrian strata of the Salt Range are similar in age to the Vindhyans of Rajputana[2] and Central India[3] —an extension eastward almost as great as that from the Salt Range to Persia. We are thus led to the conclusion that the Lower Cambrian period in southern Asia was characterised by prolonged arid conditions as a result of which the great salt-bearing formations of Persia, the Salt Range and possibly Kohat were laid down.

V.—CONCLUDING REMARKS.

In the Introduction of this paper I stated that the tentative official opinion in 1920 was, in the absence of critical field evidence,

[1] *Rec. Geol. Surv. India,* LX, 1927, p. 18, also LXI, 1928, p. 21.

[2] E. Vredenburg ("Summary of the Geology of India", 2nd Ed., 1910, p. 36), says "Lithologically the Purple Sandstone agrees with the Kaimur or Rewa Sandstone, while the remaining beds appear to represent the Lower Bhander, the same beds therefore that have yielded fossils near Neemuch." Pascoe (now Sir Edwin) informs me of his suspicion that the beds included on Wynne's map as belonging to the Purple Sandstone represent systems of different ages. He considers that, although the bulk of these beds may belong to the Tertiary, some of the mapped exposures may ultimately prove to belong to the Cambrian.

[3] Hacket, (*Rec. Geol. Surv. India,* XIV, p. 301), considered that the rocks of western Rajputana were the equivalents of the Kaimur and Bhander. LaTouche, (*Mem. Geol. Surv. India,* XXXV, pp. 26-28), agreed with this view. Murray Stuart has advanced the same opinion. I was also greatly impressed by the lithological similarity of the Purple Sandstone and the rocks of Dulmera in Bikanir.

a fair summary of the data available at that time. From a hurried study of the literature dealing with the geology of north-western India the hypothesis of a Tertiary age of the salt and the suggestion of thrust-faulting in the Salt Range appear very convincing. A close study of Wynne's writings, however, reveals a caution, which, from the pen of perhaps the most experienced observer in this area, requires full consideration. Wynne was by no means certain of the stratigraphical position of the Kohat salt deposits.[1] He had mapped the region—the only one who has done so. Neither he nor Warth appear to have been at all uncertain of the Salt Range salt; they considered it to be in its normal stratigraphical position below the Cambrian (Wynne's Silurian) Neobolus beds and under the Purple Sandstone.

The first examination of the Salt Range strata which I made was along the Khewra gorge from the mouth of the glen to the Nummulitic limestone scarp at its head. In particular I noticed the passage upward from the Purple Sandstone into the Neobolus beds (Kusak Shales of Noetling). There is a marked lithological change as well as a striking difference in colour of the strata in a few yards, and a thin gravel horizon forms a convenient base for the overlying Neobolus beds. The strata at this horizon are perfectly undisturbed and evidently quite conformable. These remarks hold true for the same horizon whether scrutinized in the Jutana cañon (see Plate 2) or on the slopes below Dandot (see Plate 8) or in the Nilawana ravine (Plate 11). It is quite 50 miles from the Jutana cañon to the Nilawan ravine.

A careful examination of the Khewra glen section of the Purple Sandstone and the strata above does reveal the existence of several relatively insignificant thrust faults. The thrusting is along an E. to W. direction and not N. and S. The amount of overlap is never more than 15 to 20 feet in the Purple Sandstone and as much as 50 to 75 feet in the Magnesian Sandstone. The inclination of the thrust planes vary from 8° to 15° inwards to the glen. In my opinion this horizontal shearing is suggestive of the weight of the cliffs on each side tending to slide into the glen. It is quite evident that the strata constitute a conformable series from the Salt Pseudomorph Beds above to the Saline series below. Although the Salt Marl is unstratified there is a rough parallelism of the rock-salt

[1] *Mem. Geol. Surv. India*, XI, 1875, pp. 28-37.

beds with the overlying Cambrian strata. All the deposits in this succession are suggestive of marine deposits in hot desert regions and thus have geographical and climatic relationships.

In the case of the salt of the Kohat area, over the geological age of which this controversy has really arisen, it has been *assumed* that the salt deposits form the lowest bed in a conformable series—the Lower Chharat. Davies' remarks on the Bahadur Khel section show that considerable irregularity and even confusion exists at the junction of the rock-salt with the overlying Tertiary beds. My opinion with regard to the Jatta exposure is that there is a great 'break' of some kind whereby strata of very different types have been brought into juxtaposition. I was unable to discover any evidence which, in a dispute, could be advanced to justify a convincing claim for conformity. All that can be safely said is that the salt underlies the Tertiary strata. Remembering the tightly folded condition of the beds throughout the Tertiary belt in the Kohat area I could not accept a Tertiary age for the salt deposits in preference to a Mesozoic or Palæozoic age. The gneissic character of the salt in the Kohat occurrences, together with its association with bitumen, and impregnation with petroleum, suggests the view that the solid salt has, as a result of great pressure, been rendered plastic and squeezed upward into intrusive relationships with a carbonaceous horizon, *i.e.*, the Laki stage. It is thus evident that, if it is impossible to settle the true age of the Kohat salt deposits in Kohat, we cannot use them for fixing the age of the Saline Series.

It is, I consider, impossible in the light of the above disclosure to correlate the salt deposits of the Kohat area with those of the Salt Range. To consider the salt beds of both these regions as of the same geological age is an assumption for which there is only the excuse of probability. Wynne and Warth appear to have convinced themselves that the salt of these two regions was not only different in quality but also in geological age.[1] These conclusions deserve attention although the suggestion of marked chemical differences does not seem to be justified by Warth's analyses (on pp. 26-27). It is quite possible that the Kohat salt is re-deposited Salt Range salt, which was dissolved after the Neobolus Beds period and deposited in Salt Pseudomorph stage times. However, any such suggestion is quite fanciful and it is far better to consider

[1] *Mem. Geol. Surv. India*, XI, 1875, p. 37 (see pp. 26-37).

all the salt deposits of north-western India of the same or approximately the same geological age. I have tried to shew that it is impossible to be quite certain of the age of the Kohat salt and that no Eocene age hypothesis will do for the Salt Range salt. No great salt deposits could have accumulated in Laki stage times. Finally all the evidence seems to me to point to a Cambrian age for the Salt Range salt and on the grounds of probability the Kohat deposits are of the same age.

My main arguments in favour of the Saline Series of the Salt Range being normally below beds of Cambrian age are:—

(*a*) No Tertiary horizon can be assigned to the Saline Series without causing confusion in the known stratigraphy. The salt is never seen on any such horizon, and the Laki stage is particularly impossible as a salt-bearing horizon.

(*b*) The occurrence of igneous material in the Salt Marl of the Saline Series of Khewra has its parallel in the volcanic rocks associated with the salt-bearing strata—the Hormuz series—of Persia, which are now considered to be of Cambrian age.

(*c*) The Purple Sandstone cannot be separated from the overlying Neobolus Beds on any argument of thrust-faulting nor on grounds of a stratigraphical 'break'. These strata are conformable and are only separable on their differences of colour and lithological character.

(*d*) The identification of the Neemuch fossils as possibly Lower Cambrian forms would make the Upper Vindhyans approximately Middle to Upper Cambrian in age. Thus the strata from the Purple Sandstones upward to the Salt Pseudomorph stage may prove to be the Salt Range equivalents of the Upper Vindhyans.

(*e*) The character of these Cambrian deposits, both of the Salt Range and the Vindhyans of western Rajputana and Central India, is suggestive of a prolonged period of arid conditions over a wide area. It is wider still if we include the Hormuz series of Persia. In such an area, for the vast period of time involved, it is evident that the salt deposits of the north-west of India could have been easily deposited.

(*f*) The anomalous position of the salt and Salt Marl in various places in the Salt Range can be easily and satisfactorily

accounted for by the isostatic subsidence and by simple solution as suggested by Christie. The foliated condition of the rock-salt in the Kohat localities is clearly the result of the extrusion of plastic salt under great pressure, *e.g.*, the dynamic forces of folding.

(*g*) The Boulder Bed (Talchir) when traced westwards from Baghanwala successively overlaps the Cambrian Strata from the Salt Pseudomorph Stage to the Purple Sandstone and Salt Marl.[1]

EXPLANATION OF PLATES.

PLATE 2.

View of the Jutana Cañon from the head of the 'falls'.

The laminated beds which cap the hill on the right of the picture are the flags and shales of the Salt Pseudomorph zone. The massive beds down to the rock face at the top of the scree are the Jutana Dolomites. Below these beds come the laminated horizon, seen in the next slope outward, of the Neobolus beds of Khusak Fort. They are as thick as the Jutana series. Below them, and beginning about the middle of the further slope, are the Purple Sandstones. These sandstones are underlaid by the Purple Shales which are seen in the base of the cliff near the curve of the stream bed. The section from the top of the Jutana Dolomite to the lowest point of the Purple Shales is roughly 800 feet. The total height of the point facing Jutana is upwards of 1,000 feet. The capping is of the Salt Pseudomorph beds. The base is of scree and hidden beneath this debris is the bright red marl of the Saline series of Khewra. The entrance to the cañon would be an excellent place to prove the strata beneath by boring.

PLATE 3. PANORAMA.

View of Khewra Gorge and village.

The cliffs on each side of the gorge are capped by Dolomite (Magnesian Sandstone), and underlaid by the Neobolus Beds, which in turn overlie the Purple Sandstone and Shales. The village is situated on the Salt Marl. The rocks seen in the distance at the head of the gorge are the Nummulitic limestones. The line of subsidence extends horizontally in the picture from the bend of the stream to the entrance of the high level tunnel. The flume can be seen on the east bank of the stream. The infiltration gallery in the stream-bed had only just been started when the photograph was taken. Minor subsidences are evident in the building on the bank of the tributary stream to the right of the salt train. The entrance to the high level tunnel is above this building. The low level tunnel is under the tributary stream-bed at a depth of about 40 to 45 feet.

[1] *Rec. Geol. Surv. India*, XIX, 1886, p. 31, also XXIV, p. 23.

Plate 4.

View looking west from the east side of the Khewra glen. Hill "1817" is seen on the left. In the middle of the picture the Salt Marl with outcrops of rock salt and included lenticles of gypsum is seen to strike westward to the Dandot valley. A close examination of this photograph will reveal the overfolded condition of the Salt Marl. It will be also evident that the overfold is more suggestive of an extrusive origin than it is of any other explanation, especially as the strata on each side—the Purple Sandstone, etc.—are never found to be bent or buckled although they are tilted and fractured. The explanation is given in Fig. 6, with which Fig. 7 should also be studied. The mining village of Tobra is seen on the right of the picture on the heights which overlook the Salt Marl.

Plate 5.

View looking up the subsidence in Khewra village.

The line of the subsidence covers the concealed outcrop of a seam of rock-salt which evidently crosses east-north-eastward through the saddle. The hills to the left above the village consist of debris of bright red saline marls with fragments of dolomitic limestone and gypsum. This material though soft and plastic stands at a relatively high angle (of repose).

Plate 6.

View of Dandot plateau, from Hill "2666" south of Pidh, looking south-east. The river Jhelum is seen beyond and on a fine day the Kirana and other hills of the Jech and Rechina Doabs (*Rec. Geol. Surv. India*, XLIII, pt. 3, 1913, pp. 229-236) can be clearly seen. The Dandot plateau is capped with Nummulitic Limestone and the step in the scarp at A shows the village portion of the plateau to have slipped downwards. The greater dip in the lower beds is clearly seen on the slopes of Hill "2340" where the Cambrian strata underlie the Boulder Bed and Speckled Sandstones of the summit. The dark beds in the middle of the picture are Speckled Sandstones and the Boulder Bed overlying the Salt Pseudomorph Beds so that there must be a fault or slip between it and the Dandot plateau. Hill "2666" is capped with Nummulitic Limestone with the Laki coal-bearing horizon on a level with the terrace in the foreground of the picture. It is thus seen that a considerable amount of slipping or subsidence has taken place between Hill "2666" and Hill "2340" as though the plateau had itself sunk bodily.

Plate 7.

View from Dandot plateau south-eastwards with the plains of the Jhelum valley in the distance. The village of Dandot is seen on the cliffs in the left of the picture. The coal measures lie in the saddle where the workshop buildings are seen and their outcrop follows round to the mine seen in the foreground. The beds under the coal are not clearly exposed, but they are roughly 100 feet below and overlie

the Speckled Sandstone and the Boulder Bed of Hill "2340." This Hill "2340" above the workshop buildings and forming the central feature in the photograph, shows the dipping strata of the Speckled Sandstone (Conularia beds). On the outward slope of this hill, underlying the Boulder Bed, are successively the Salt Pseudomorph Beds, the Neobolus Beds and the Purple Sandstones and Shales with the gypsum band below. Then follow the inverted beds of dark Purple Shales and Sandstones, which are seen on the right of the picture. The light coloured strata at A are the Salt Marls which were seen and discussed in connection with Plate 4. Hill "1817" capped with Magnesian Sandstones is also seen.

PLATE 8.

View from Hill "2061" looking eastward. In the foreground is the Uchli Kas glen. Dandot village crowns the Nummulitic scarp to the left (north). Hill "2340" with the great unconformity between the Talchir Boulder Bed (Upper Carboniferous) and the Salt Pseudomorph Beds (Upper Cambrian) are indicated. The gypsum band between the normal and inverted strata is also clearly seen. All the beds below the gypsum band are overturned. The Purple Sandstone and the Neobolus Beds are seen repeated. If a thrust-plane lay between the Purple Sandstone and the Neobolus Beds it is evident that the thrust plane would also be included in the fold. This photograph thus proves that the Purple Sandstones cannot be separated from the Neobolus Beds on structural grounds and the beds are obviously related stratigraphically.

A curious sink-hole subsidence is seen in the Uchli Kas and the fact that a large mass of strata are seen to be sunk in the Salt Marl across the Dandot valley (see right of picture) on the same line of strike as the axis of the inverted beds is suggestive of subsidence rather than overfolding to account for the section seen in this photograph. The sunken mass above-mentioned is well seen in Plate 9.

PLATE 9.

A continuation of the Dandot section seen in Plate 8, and also taken from Hill "2061" looking eastward. The inverted Cambrian beds—the gypsum band at the base of the Purple Shales, the Purple Sandstones and particularly the junction between the Purple Sandstone and the Neobolus Beds, are all clearly seen. The sunken mass of Cambrian strata embedded in the Salt Marl across the valley is also evident (see Plate 10).

PLATE 10.

Is a view looking east-south-east from the saddle, between Hill "2340" and Dandot village, at top of incline. Hill 1817 with its cap of Magnesian Sandstone is seen in the distance with the Jhelum river beyond. The belt of Salt Marl and rock-salt outcrops which trend into the Khewra glen is seen in the middle of the picture. The sunken mass of Neobolus Beds with a capping of Magnesian Sandstone and a plinth of Purple Sandstone is seen, surrounded by the bright red Salt

Marl, just above the post of the distant signal. The tubs are filled with limestone (4) and coal (2). On the left of the picture the Cambrian strata are seen *in situ* on the main cliff face.

PLATE 11.

This is a view from below the summit of Hill "2340" south of Dandot looking westward to Hill "2061" and the Jhelum river beyond. The gypsum band G is clearly seen to be conformable to the underlying strata. In the foreground are seen the Salt Pseudomorph Beds. The man on the right is standing in front of the little cliff which is the base of the Boulder Bed. The glen below is the Uchli Kas. Kurlnia lies at the entrance to the gorge, seen on the left of the picture, which leads up into the Uchli Kas. Salt Marl is seen in the foot-hills on the left. The dark rocks seen at the bottom left-hand corner are inverted Purple Sandstones. The strata lying in a normal position are seen on the spur which joins Hill "2061" with the foot of the Dandot scarp to the north (right).

PLATE 12.

Banded rock-salt in the Nilawan Ravine. Tilted, faulted and squeezed strata of the Saline Series which suggest tectonic movements in the Salt Range. The mass is really partly slipped and partly up-heaved material. The whole appears to have subsided as the result of the solution and wetting of the soft clayey material of the Saline Series. The pressure of the strata of the main slope has squeezed out the plastic salt and saline marl under and into the ravine bed. Looked at closely it will be seen that the section across the ravine is that of a low anticline, the tilt away from the gorge being due to the pushing out, up ward, of the plastic, wetted marl and rock-salt of the Saline Series. The cutting action of the stream disturbs the isostatic balance by removing material from over the plastic beds, and this, as a result of the pressure of the strata on the main hills on either side, has pushed up into the ravine floor.

PLATE 13.

View looking up the Nilawan Ravine. The Saline Series of rock-salt, gypsum and bright red saline marls, are seen on the right bank of the picture. These strata are overlaid by the shales of the Khewra stage (Purple Sandstone) and then by the sandstone. The spur at the right top is capped by the Kusak (Neobolus) Shales while the main scarp to which this spur is joined is capped with the Jutana Dolomite (Magnesian Sandstone). A gentle anticlinal structure across the valley is fairly evident the dips being somewhat steeper in the lower beds in the sides of the ravine as though the valley floor corresponded with an axis of bending due to the localized pressure of some underground heave.

PLATE 14.

View looking back (south) down the Nilawan Ravine. The pinacle on the left is Purple Sandstone (Khewra stage) underlaid by purple shales with the Saline

Series showing in the base of the slope in the ravine. The massive Purple Sandstone is seen forming the plinth of the bluff in the middle of the picture. The overlying soft beds are the Kusak (Neobolus) shales, while the bluff is surmounted by the Jutana Dolomite (Magnesian Sandstone) with a thin capping of the equivalents to the Baghanwala (Pseudomorph Salt Beds) zone. The dark, somewhat broken strata on the right of the ravine are Purple Sandstones which have subsided or been faulted down. The slipping of smaller material is evident on the slope below the pinnacle.

PLATE 15.

A view in the Warcha defile above the Salt mines and on the way up to the newly opened prospecting adits. The interest in this photograph lies in the fact that rocks older than the Saline Series show up in the valley bed. In this picture these folded strata are seen under the Salt Marl. There is an exposure of rock-salt half-way down the cliff face under the little guard hut which is seen on top. I was not able to determine if these folded flaggy and shaly beds (impregnated with salt) were part of the Saline Series or truly below these strata. This locality would be a suitable place to put down a boring from which considerable information might be obtained.

PLATE 16.

The Salt Hill of Bahadur Khel (Kohat district). The banding may be the original bedding of the rock, so far as one can guess, while the puckering seen on the righthand side is responsible for the schistose nature of the Salt. Murray Stuart considered the banding as due to foliation planes. It is quite possible this "metamorphic" explanation is the correct one but it is difficult to decide. The chemical nature of the Salt, except for included earthy matter, does not vary greatly.

PLATE 17.

Pseudomorphs of clay after Rock-Salt. The little cubes of salt appear to be attached to the under-side of the flaggy layers and to project into the soft red clay which is below. There is a thin parting of green (glauconitic) clayey matter between the red clay and the flaggy layer to which the pseudomorphs are attached. These Pseudomorph Beds are best exposed on the track leading from Baghanwala to Ara, and this horizon is most appropriately designated the Baghanwala beds.

THE IRON ORE DEPOSITS OF THE NORTHERN SHAN STATES. BY J. COGGIN BROWN, O.B.E., D.SC., M.I.M.M., M.I.M.E., *Superintendent, Geological Survey of India.* (With Plate 19.)

INTRODUCTION.

IRONSTONE mining in the Northern Shan States is carried on exclusively by the Burma Corporation Ltd., and the ores so obtained are used in the blast furnaces at Nam Tu to assist in the reduction of sulphide ores containing lead, silver, zinc and copper. For this purpose they are essential, so that although the quantities raised are small in comparison with those won in India to supply iron and steel works there, the industry in the Shan States is a settled and important one. It has already opened up new tracts in this somewhat remote region and found employment for both local inhabitant and Chinese immigrant alike; moreover, it is very probable that it will continue to do so for some considerable time to come.

My first acquaintance with this branch of the Corporation's activities was in 1916 when I reported on the Twinnge deposit, then under exploitation. Early in 1927, the Government of Burma requested me to review the iron ore situation generally. Other duties having taken me to Bawdwin, I spent a few days on my return journey, with the permission of the Director, Geological Survey of India, in the Wetwin neighbourhood, in March last, and I was also enabled to examine briefly the Manmaklang deposit as well. In this report I propose to summarize briefly our knowledge of the outlying deposits which have been worked, before dealing with the mines of the Wetwin area proper. In Rangoon before leaving for the field I had the advantage of a discussion with Mr. P. E. Marmion, Managing Director of the Corporation, at that time on a visit to Burma, while Mr. E. Hogan Taylor, General Manager in Burma, conterred with me at the mines. To both these gentlemen my best thanks are due.

OUTLYING DEPOSITS.

THE TWINNGE DEPOSITS.

Iron ores were probably mined in this vicinity in the times of the later Burmese kings but P. N. Datta in a note published in 1900,

was the first geologist to draw attention to them.[1] He found outcrops of apparently rich iron ore between the third and fourth furlong posts, past the 39th mile on the Mandalay-Lashio cart road, that is, 2½ miles beyond the village of Singaung (Zegon, 21° 58′ : 96° 27) or about 3 miles south-west of Maymyo. Regarding Twinnge itself Datta wrote as follows :—

"About half a mile north of a little village called Twinnge which lies a little over 2 miles due north of Thondaung railway station is a hill whose top, *i.e.*, so much of it as is exposed, shows masses of a very rich iron ore, probably hæmatite with magnetite......... There is no doubt that it is very rich stuff, but the ground round and about must be a little more cleared before one could estimate with any degree of certainty as to the quantity of ore here, which is apparently large."

Several years later the Burma Corporation commenced quarrying near Twinnge (21° 57′ 30″ : 96° 25′), and in 1916 I found that the ore occurred in rounded grains, pebbles and masses, sometimes several feet in diameter, forming a layer near the base of the mantle of red clay which overlies the dolomitic limestone of the Shan plateau.[2] The ore bed had an average thickness of about 3 feet and the quantity originally available was estimated at approximately 275,000 tons. The composition of the ore is given in the two following average analyses, the first of which represents the ore as delivered to the smelters for the four months ending December 1914, and the second for the three months ending March 1915.

	Insoluble.	Iron.	Alumina.
	Per cent.	Per cent.	Per cent.
No. 1	10·2	56·3	3·4
No. 2	6·4	60·1	3·4

I came to the conclusion that the ore was of a residual nature, and represented the ferruginous matter originally disseminated through that portion of the limestone which has been removed by denudation, since the Plateau permanently emerged from the sea in later Mesozoic times.

[1] P. N. Datta : "Notes on the Geology of the country along the Mandalay-Kunlon Ferry Route, Upper Burma." *Gen. Report, G. S. I.*, 1899-1900, pp. 121-122.

[2] J. Coggin Brown : "The Iron Ore Deposits of Twinnge, Northern Shan States." *Rec. Geol. Surv. Ind.*, XLVII, pp. 137-141.

THE MANMAKLANG DEPOSIT.

This deposit lies 2 miles east of Manpwe and 2½ miles from a siding on the main railway line, in lat. 22° 50′ : long. 97° 40′, at the foot of a north-east, south-westerly trending limestone range, in a country of low relief, the surface of which slopes gradually in a north-western direction towards the Nam Yao river. Work was commenced in 1917, and in 1922, E. L. G. Clegg visited the mine but finding the workings full of mud and water owing to their temporary abandonment, he had to rely on data, supplied by the Corporation's geologist, Mr. E. H. Loveman.[1] According to the latter, the country rock is limestone, and the iron ore was exposed in tunnels and shafts, not as separate boulders but rather as a mass of fragments separated by slight amounts of clay and by open crevices. Towards the south-east the ore was covered by 10 feet of travertine but with the exception of this junction and one other at the bottom of a shaft 40 feet deep, where the ore lay directly on the limestone surface, all the contacts were with the surface soil. These facts led Loveman to believe that the Manmaklang deposit was of residual origin, an interpretation which does not seem to me to be in accordance with evidence which more extended exploration has made available.

I regard it as a large replacement deposit, the result of the action of iron-bearing waters of meteoric origin working downwards on the Plateau Limestone, which is exceedingly brecciated and soft hereabouts. Originally opened up by two drives, separated by a vertical height of 75 feet, and by two shafts, it has since been developed into a large open quarry in which the upper drive is now exposed. According to Clegg, this passed through 115 feet of ore and its face was still in ore in 1922, while shaft No. 1 had been sunk 75 feet in ore and discontinued at that depth. Mr. G. Rogers, the Superintendent of the ironstone mines of the Company, informed me that while the Manmaklang deposit was at least 200 feet long and 150 feet broad at the surface, it was said to have diminished to a thin, 12 to 15 feet band in the lower drive.

At the time of my visit the full width of the orebody could not be seen, owing to surface falls, but there was a well marked wall visible. The ore itself appears to be mainly limonite of varying

[1] E. L. G. Clegg: "Kungkha and Manmaklang Iron Ore Deposits, Northern Shan States." *Rec. Geol. Surv. Ind.*, LIV, pp. 431-435.

shades of yellow and brown,[1] a light, rather porous material containing, however, irregular bands and lumps of darker and harder mineral in which hæmatite seems to predominate. Prominently exposed in the quarry face was a large lenticular mass of marcasite.

The output from Manmaklang was about 1,300 to 1,500 tons per month, operations being carried on by Chinese labour in the open season only. The larger and richer material is handpicked, the remainder is carted to the log washing plant which separates dirt and an ⅛ inch undersize. From the log washer a narrow gauge railway proceeds to the siding on the main line.

The following table gives the approximate composition of the Manmaklang ores :—

	Iron.	Silica.	Alumina.
	Per cent.	Per cent.	Per cent.
Lump Ore	57	2	Not stated
Washed Ore. . . .	54	3·5	2
— ⅛ Fines	47	6	Not stated

These may be compared with the following approximate assays given by Clegg :—

Iron.	Silica.	Alumina.	Lime.
Per cent.	Per cent.	Per cent.	Per cent.
52	1·5	6·5	1·8

Open cast working will be impossible at Manmaklang before long, without costs which may well be prohibitive. It is rapidly becoming an underground proposition and in this case the limits quoted by Mr. Rogers have to be borne in mind. It is clear that such operations cannot be carried on profitably in competition with surface work on the true residual deposits elsewhere, though Manmaklang possesses an advantage over the Wetwin region by reason of its proximity to Namyao, the terminus of the Corporation's own railway.

The Man Pat Deposit.

Quantities of a small-grained, yellowish, rubbly iron ore are carted to the Manmaklang washing plant from Man Pat some 6 or 7 miles to the south-east. These bring up the combined output to about 3,000 tons per

[1] The term "limonite" is used to include mixtures of any or all of the hydrated oxides of iron. They are of red, yellow and brown tints and often have an open, cellular texture.

month. Time did not permit to visit the area but I understand that the deposit is a shallow residual one lying on limestone.

Residual Deposit at Manmaklang.

Close to the large quarry at Manmaklang there is an interesting residual deposit consisting of the typical red earth of the Plateau crowded with small pellets of limonite and similar ores. Although a certain amount of excavation had been done, the limestone bed-rock was unfortunately not exposed. Analyses of these pellets in the Corporation's laboratory have shewn them to be too aluminous for the special purpose for which they are required. The high alumina content may be due to small pieces of a white bauxitic mineral which occur with them and which cannot be separated in the log washer. It is also possible that the kernels of the pellets themselves are responsible for it.

Prospecting near Manmaklang.

About half a mile south of the main quarry a long trench had been dug up a steep hillside and had exposed pieces of iron ore similar to that found in the quarry. Both this trench and others at right angles to it were not deep enough at the time of my visit to enable any useful conclusion to be made. As a prospect it showed possibilities worthy of further exploration.

THE KUNGHKA DEPOSIT.

I have not seen the Kunghka deposit which lies in lat. 23° 13′: long. 99° 19′, 17 miles from Nam Tu, where the ore is brought by pack mules. According to Clegg, work was commenced here in 1916 and some 5,000 tons had been removed up to April 1922. To-day it produces about 7,000 tons during the dry season only. It is said to be situated on the Pangyun beds, a name given by me to a group of rocks lying between the Bawdwin Volcanics below and the Naungkangyi series of Ordovician age above, with which it is conformable.

The ore body is in a fault zone and has been formed by the infiltration of iron-bearing solutions resulting in the production of lenticles and veins of hard solid hæmatite in a soft matrix of red and yellow limonite. In the latter, platy crystals of specular iron ore and small nodules of barytes are of frequent occurrence. Occasionally much larger masses of barytes are found, several of which were recently presented to the museum of the Geological Survey in Rangoon by the Corporation. The mineralisation has also affected

the contiguous sandstones of the country rock and their cementing material has been altered to iron oxide. It is interesting to note that Clegg and Messrs. Loveland and Bloomfield, the latter geologists at one time in the employment of the Burma Corporation, believe that the iron of the Kunghka veins was probably derived from Plateau Limestones which originally overlaid the Pangyun series. Kunghka ore in the stock heap at Nam Tu was a typical hard hæmatite. It is used coarsely crushed in the production of copper matte only. Clegg has given the following analyses:—

Kunghka ore (hard type)	Fe=61 per cent.*
,, ,, (soft type)	Fe=47 ,,

* Average of 2,500 tons.

DEPOSITS OF THE WETWIN REGION.

THE PAUKTAW DEPOSITS.

The Pauktaw quarry is close to the main railway line, some 4½ miles south-west of Wetwin station in the direction of Maymyo, and about half a mile from the Pauktaw camp and log washing plant of the Corporation. It is a small excavation which was worked in 1920 and 1921. Originally the iron ore cropped out at the top of a small hill and as it was followed down, the workings gradually increased to a depth of 35—40 feet. In the old faces I found the lower layers of the red earth containing shots of iron ore while at the bottom was an ore bed 8 to 10 feet thick—massive in parts but more commonly with an "organ-pipe" structure. 1,700 tons of ore averaging 56 to 57 *per cent.* of iron have been removed from this hole. There are no indications of exhaustion but the economic limit has been reached because of the increasing thickness of the overburden.

THE BAWHLAING DEPOSIT.

Bawhlaing is about 2 miles to the north-north-east of Pauktaw camp. I visited the abandoned workings on my return journey from Naungthakaw. They commence as a channel some 200 feet across and soon broaden out into a semi-circular excavation about 500 or 600 feet in diameter. Their total length, including the channel, is 1,200 or 1,300 feet. From this area approximately 200,000 tons of good massive ore have been taken and there is still a reserve of

roughly 40,000 tons left. It was a shallow deposit lying on the top of a limestone knoll which displays the typical form of weathering so prevalent in this region. The deep reddish-purple soil is very characteristic. I noticed a thin deposit of pisolitic ore which is said to be too high in alumina to be worth washing. Pitting is reported to have been carried on all around but has revealed no extension of the ore bed except on the higher ground, and here it is too thin to be economically removed.

THE NAUNGTHAKAW DEPOSITS.

The Naungthakaw lease lies six miles as the crow flies to the north-west of the Pauktaw camp of the Corporation, about lat. 22° 10′ and long. 96° 31′, on Sheet 93B/12 of the 1 inch to 1 mile Survey. It is on ground which slopes gently towards the valley of the Shweleik-ka to the south and to the north-easterly flowing drainage on the east. To the west is the higher land attaining elevations of over 4,000 feet, along which the boundary between the Mandalay district of Upper Burma and the Federated Shan States runs.

The leased area has been divided into a number of sections, lettered from A to O, whose general position can be seen from the accompanying plan (Plate 19).

Section A.

In Section A, the workable ores occur between elevations of 3,650 and 3,700 feet, varying from thin bands a few inches across in the north-west and south-east to richer stuff several feet thick, distributed in three well defined patches in the middle of the southern half of the section. In one large open cut of this section, from which the red earth had been stripped for two or three acres, the limestone cropped out on the south-south-west, while towards the opposite direction the overburden thickened beyond the present economic limit. This occurrence illustrates an important point. On the attached plan, the approximate limits of the ore bodies in the various sections are outlined, but it must be remembered that these are the limits of the ore which can be extracted profitably at the present time by prevailing methods. They are not the absolute limits of the ore bodies in all cases, but are governed by such factors as depth of overburden, thickness of the ore band and composition of the material. The average thickness of the overburden in the open cut is about 8 feet and under this is some 6 feet of vesicular hæmatite bearing indications of a little manganese ore.

Stripping was in progress in another part of Section A, the upper and untouched surface of the ore bed being exposed over a large area. The original recoverable contents of this section were estimated at 16,000 tons. (These and similar figures given later, are the estimates of the Corporation's engineers which, together with the plan, were courteously placed at my disposal.)

Sections B, C and D.

To the north of Section A lie Sections B, C and D. Sections B and C are separated from Section A by a shallow depression carrying a little stream which may be responsible for the break in the ore band between them. Further east again are low prominences which should be tested. In Section B, the thickest part of the ore bed is found on and about the summit of Kadut Taw hill, elevation 3,780 feet, where it practically comes to the surface. The overburden thickens down the slopes while the ore bed diminishes to 6 inches in the valley towards Section A. After thinning in Section B, the bed becomes very well-defined again in Section C, at elevations between 3,660 and 3,740 feet, with extensions again, as shown, into the southern part of Section D. A good deal of the ore in these blocks is roughly rounded, rubbly material rather than the cemented solid ore of Section A. The estimates for Sections B, C and D were 35,000, 50,000 and 6,700 tons respectively. It would be advisable to pit closely the unworked portion of Section D along the contours where the ore occurs in Sections B and C.

Sections L and E.

Section L lies to the north and west of Section D and is followed to the north by Section E. An ore bed commences in Section L and stretches across Section E to its northern limits. It lies between the 3,650 and 3,750-foot contours and is exploited. The two blocks have been estimated to contain 10,000 and 25,000 tons of ore respectively. The open cuts in these blocks display the extremely irregular surface of the underlying limestone in a remarkable manner, high pointed pinnacles separated by deep and narrow hollows being of common occurrence. In the latter, pockets of brittle, rubbly hæmatite up to 20 feet in thickness lie under 6 to 8 feet of overburden. In one exceptionally deep hole in a quarry of Section E, the ore is 40 or 50 feet thick and of a very solid, brown hæmatite at the bottom, while surrounding it are rocky pillars with only a few feet of ore above them. The lower layers of the red earth in both these sections contain a good deal of small disseminated rubbly ore which is recovered by dry screening.

Sections F and G.

Sections F and G lie to the north of Section E from which they are separated by a barren area. I did not examine these two blocks though they have been proved to contain ore beds with estimated contents of 12,000 and 23,000 tons respectively. Stripping operations were in progress on Section G at the time of my visit. In both of them the ore occurs at much the same horizons as elsewhere in the lease.

Sections M and I.

To the south of Section E lies Section M, to the north of which again is Section I. In addition to several small patches of good ore, Section M contains the southern portion of an ore bed, which obtains its greatest development in Section I and contains approximately 55,000 tons. The estimate for Section M is 11,000 tons. One quarry in Section I is over 50 feet deep between higher banks of limestone. The ore in both is of a rubbly and vesicular nature, but large boulders of harder material up to 6 feet in diameter, require blasting before they can be handled. The overburden ranges up to 12 feet thick and the greater part of the ore lies about the 3,700-foot contour.

Sections J, K, O, H and N.

Sections J, O, H and N form a parallel group to Sections M and I on the east extending from south to north with Section K to the east of Section J. In these areas the ore beds are found between elevations of 3,650 and 3,680 feet. Section J is a good block which contained 50,000 tons. Its limestone bed rock is more deeply eroded than elsewhere on the concession and one pipe, almost circular in section, had a depth of 35 feet with its bottom still in ore at the time of my visit. A separate ore bed in the eastern part of this section extends into Section K where some 3,500 tons are already proved. In Section O, unmarked on the plan, but lying between Sections J and H, pitting was in progress over an area of 7 acres and a considerable extent of ore bearing ground had been proved. The overburden, however, was unusually thick. The ore bed in Section H, with an estimated reserve of 36,000 tons, lies between the 3,660 and the 3,680-foot lines and that in Section N between 3,630 and 3,650-foot, with a reserve of 13,000 tons.

PROSPECTING OPERATIONS AROUND NAUNGTHAKAW.

In addition to the ore winning operations which are being carried on in the sections of the Naungthakaw leased area already described, the Corporation is engaged in a prospecting campaign elsewhere.

One line of country along which work was being prosecuted commences from Section I and trends to the north, though no pitting has been done for three-quarters of a mile north of the last ore bed that has been proved. Other areas which were being systematically tested are known as the "3 mile north block" and "Taungtalon east block." On the "3 mile north block" at the time of my inspection, over 400 pits had been sunk, many of which revealed good thicknesses of ore. As a rule, there is little surface indication of the presence of underlying ore beds but at a point half a mile west of Nyaung-bin-tha, pieces of coarse hæmatite were picked up in the fields. Prospecting operations were being carried out both here and elsewhere in a methodical and skilful manner, the only complaint which I have to make is that pitting is not permitted in land under cultivation, or in land intended for crops during the following rainy season. As all the cultivation is of the *taungya* variety, and as the pits are refilled as soon as their contents have been measured and examined, I fail to see why such a restriction should be made, especially as the Corporation is willing to compensate for any reasonable injury or loss caused to cultivators during its explorations. In repeated instances I found lines of pits stopped because the jungle ahead was being cleared for a *taungya*. A system of this kind quickly leads to abuses and it is impossible for the Corporation, or any other body, to compute the iron ore reserves existing in this region, if its activities are restricted to narrow wandering areas lying between present and potential patches of hillside cultivation.

In a tour which I made through the "3 mile north block" and elsewhere, I found pitting in progress at Tanganaing with comparatively poor results. The prospects beyond Thayetkon and around the point marked 3,618 on the 1-inch survey map, appeared good, but no pitting has yet been undertaken there. The lower slopes of the Taungtalon limestone hill are well worth testing, but work is suspended as they are under cultivation, though there is known to be a patch of ore in a small valley between that peak and another one to the south-east. Beyond advising the intensification of the pitting campaign and an extension of preliminary pilot holes in suitable localities towards the north-north-east, if it was considered desirable to add to the total iron ore reserves quickly, I could suggest nothing else to the capable officials of the Corporation engaged in these tasks. As about 200,000 tons have been added to the

available reserves as a result of the season's work, this policy would appear to have been justified.

FUTURE PROSPECTS.

The questions may be asked, what are the prospects of obtaining additional supplies of iron ore in this region? Will they be large enough to relieve the anxieties of shortage for years to come and warrant the laying down of proper means of transport to replace the bullock cart, if they come to be worked further away from the railway?

To answer these questions we must consider briefly both the geological features of this portion of the Shan Plateau and the origin of the iron ores which are found upon it.[1]

The great series of dolomitic limestones of Devonian to Permo-Carboniferous age which are called the "Plateau Limestones" cover hundreds of square miles in the Shan States and stretch beyond them into China. In the region under discussion, which may be taken as a roughly triangular area with its base formed by the railway line between Maymyo and the Gokteik gorge, and its apex the peak Hpataungyi (3,564 feet) in Mönglong sub-State, they form an embayment, surrounded on the west and north by the higher, hilly country of the eastern part of the Mandalay district and of Mönglong, covering thus about 420 square miles. Encircling the limestones are various groups of older rocks which it is not essential to consider here. The residual iron ore deposits are confined to the limestone and are not found beyond its limits. The boundaries of the limestone with the older rocks, for the most part mudstones and shales of Ordovician age on the west, and sandstones of the Silurian period on the north, have been mapped by La Touche and are clearly defined. Commencing on the south at Mogyobyit, 4 miles north-east of Maymyo, the boundary continues north, across the eastern slopes of peak 4,167 through Taungtonlon to Kyaukme; here it turns west for 3 miles to Memauk, whence it continues north through Hsa-pye-do, Kyauk-mo and Loikaw. From this point it begins to trend north-east and swinging round the head of the embayment is found again, trending south-east now through Na-Kyang, Pyinmana

[1] The remarks which follow apply only to the residual ores such as those of Naungthakaw and the Wetwin region generally, and not to particular and exceptional cases like the replacement deposit of Manmaklang or the true vein formation of Kunghka.

and Pangu, whence it follows approximately the course of the Nam Panhse stream to Chaungzon. The embayment is drained mainly by a network of sluggish streams flowing to the south-east through the comparatively low area around Hsum-hsai. This place has an elevation of 2,623 feet, but the limestones ascend to heights of over 4,000 feet in exceptional cases. The older rocks beyond it form higher ground still, and the limits of the plateau are quite apparent from the contrasting sculpturing of the country, even on a plain topographical map.

In the embayment just outlined, as elsewhere, the limestones are covered for the greater part with a mantle of red earth. Of prevailing Indian red or reddish-purple tints this attains depths varying from a few inches to 40 or 50 feet. It contains little or no sandy matter, is usually stiff and tenacious in character and is sometimes full of pisolitic nodules of iron oxides and hydroxides, ranging in size from small shot upwards. La Touche compared the red earth with the "terra rossa" of Istria and Dalmatia and thought it might have been produced by a process of lateritisation, the difference between the final products and ordinary laterite being perhaps due to the absence of siliceous matter from the limestone. Its origin can only be attributed to the accumulation of the insoluble matter in the limestone itself in the course of its degradation through weathering. It is true that these dolomites contain very little insoluble matter; in four analyses by the late T. R. Blythe the average found was 1·09 *per cent.*, while four more, by the chemists of the Corporation, only yield an average of 0·4 *per cent.*: but on the other hand, the area is believed to have been a continental one from later Mesozoic times.

If the red earth is a residual deposit its iron contents are also of the same origin. At one time disseminated in small quantities through the dolomites (and Blythe's analyses again average only 0·76 *per cent.* for the combined oxides of iron and aluminium), they were at first probably equally well distributed through the red earth, and their concentration into the irregular beds towards the base of the clay, as we find them to-day, is due to subsequent processes which have occurred in it since its formation. There are no signs that the iron ore occurred in the limestone in any form of concentrated deposit, neither are there the slightest indications in this type of deposit that it is of bog or lacustrine formation, or has been produced by any kind of replacement.

It follows that iron ore beds should be found in many suitable places on the plateau, where the thickness of the red earth is sufficient for the chemical reactions which have resulted in the concentrations to have taken place, and the topographical conditions are such that they have not been removed at later periods. With this in mind, when dealing with the Twinnge deposit in 1915, I wrote as follows :—

"Other similar deposits exist in the immediate neighbourhood. The surface of the ground shows the same type of light brown ferruginous gravel and larger pieces of iron ore. In more distant parts of the Shan plateau they will also be discovered when carefully searched for. Recently I have noticed the same indications between the villages of Wetwin and Padaukpin and also a few miles south of the latter locality, though whether the ores exist here in paying quantities or not has still to be determined."

These views have been abundantly confirmed by the developments of recent years, though the Padaukpin ore itself proved to be of much too bauxitic a character to be of any value in lead smelting. For some reason which I am unable to explain at present, the ores from the lower portions of the plateau, and also the small pisolites which occur frequently in the upper portions of the red earth, are often highly aluminous and it is to the higher geographical horizons and well-drained gentle slopes, at elevations such as have been indicated earlier, that future attention should be paid. A zone of country possessing these features runs almost completely round the embayment, and it is in this, not far from the boundaries of the older rocks, and yet not too close down towards the waterlogged centre, that conditions are, in my opinion, most promising. Experience gained since 1915 convinces me that further extensions of the iron ore deposits will be located in such situations, neither are they likely to be confined to this particular limestone embayment, which I have selected as a convenient unit, because the present operations of the Corporation are centred in its southern corner, and form a suitable point of attack for the exploration of the rest, besides embracing a tract of country well adapted for opening up, either by a good motor road or a light railway. If prospecting operations are desired further afield, the middle slopes of hill 4,378 and of Taungma, to the south and east of Wetwin, are suggested, though I consider an extension of the present scheme to the north as much more likely to lead to quick results.

Iron ore deposits of this type and in this country are notoriously irregular. The exhausted portions of the Naungthakaw blocks show how extremely variable the character of the surface of the dolomites may be. The general impression that it is a more or less flat underlying table is entirely wrong. It is weathered into fantastic heights and hollows which reproduce on a small scale all the "pitons" and chasms of a karstic landscape. Such a scene explains how one prospecting pit may miss the ore bed entirely, while the next one, landed on a hole in the limestone full of ore, may make an excellent though misleading showing. Close and careful pitting is essential before estimates can be attempted, while lines of pits should not be stopped because one or two holes yield poor results in succession. Instances have occurred where a good ore sheet has thinned away to practically nothing, down towards an insignificant surface drainage channel, to make again in quantity on the opposite slope.

ECONOMICS.

The Pauktaw deposit was opened up in December 1920 and the Bawhlaing one in January 1921. The sinking of prospecting pits commenced on the Naungthakaw lease in 1921 and exploitation started in 1922, since when 35,000 to 40,000 tons have been removed *per annum.* All the work is open cast, large areas being stripped of overburden and the ore beds systematically removed. The larger pieces of ore are handpicked whilst the remainder is dry screened on the spot, carted to Pauktaw, cleaned in a log washing plant and railed to Nam Tu from a siding at the plant alongside the main line. The labour force is about 1,000 strong and consists for the most part of migratory Yunnanese Chinese and Maingthas with some local Shans. Mining operations are suspended during the rainy season. The carting is done by local people who work intermittently removing loads of about three-quarters of a ton. Up to 400 carts a day can be collected if necessary. About 40,000 tons of ore are kept in the stock heap at the siding. The log washer works continuously throughout the season except when the water supply is required by cultivators. Efficient arrangements are made to settle the slime from the plant and prevent its overflow on to terraced rice fields. The rates paid for prospecting pits vary from 6 annas to Rs. 1-12 per foot, according to depth; the latter rate is unusual and is only given for deep 30-foot holes, in which hard ore has been

encountered. In lines of holes, pilot pits are sunk 200 feet apart, and intermediate ones 100 feet apart are put down if warranted. Pits are filled in after inspection and measurement.

ANALYSES.

A series of analyses illustrating the composition of the ores from the Naungthakaw and other mines is given below :—

(1) Washed ore as railed :—

FeO	=71—72·5 per cent.	
Al_2O_3 . .	=3·3—3·5 ,,	
SiO_2	=4—5 ,,	

(2) Washed ore (fines) :—

Fe	=56·2 per cent.	
Al_2O_3 . .	= 0·3 ,,	Sp. Gr.=3·1.
SiO_2	= 4·4 ,,	

(3) Bright red hæmatite (brittle 1., slickensided ore) 2. from Section E :—

Fe	=61·3 per cent.	64·5 per cent.
Al_2O_3 . .	= trace	trace
SiO_2	= 5·0 per cent.	2·8 per cent.

(4) Bawhlaing ore :—

Fe	=56·6 per cent.
Al_2O_3 . .	= 3·7 ,,
SiO_2	= 2 ,,

(5) Pisolitic material from Pauktaw cutting :—

Fe	=25·2 per cent.	
Al_2O_3 . .	=19·0 ,,	
MgO	= 6·2 ,,	Sp. Gr.=2·57.
MnO_2 . .	=11·2 ,,	
SiO_2	=10·0 ,,	

(6) Bauxitic ore from Padaukpin :—

Fe	=21·2 per cent.
Al_2O_3 . .	=49·4 ,,
SiO_2	= 9·8 ,,

(7) Dolomites ; Average of 4 specimens :—

CaO	=30·5 per cent.	
MgO	=20·1 ,,	Sp. Gr. varied from 2·75 to 2·83.
Insoluble . .	= 0·4 ,,	

My thanks are given to Mr. E. Hogan Taylor, the General Manager of the Burma Corporation Ltd., who accompanied me to Manmaklang and Pauktaw, for his help and unfailing courtesy, to Mr. G. Rogers, in charge of the ironstone mining operations, who kindly guided me through the Naungthakaw region, and to his assistants, Messrs. Peart, Hosking, Fleming and Patterson for their knowledge placed freely at my disposal and for their hospitality.

THE LOWER CANINE OF AN INDIAN SPECIES OF CONOHYUS. BY GUY E. PILGRIM, D.SC., F.G.S., F.A.S.B., AND N. K. N. AIYENGAR, M.A. (With Plate 20.)

The present find.

The mandible which forms the subject of the present paper was collected in the early part of 1927 from the Kamlial stage of the Lower Siwaliks from a locality ½ mile NE. of the village of Sadrial near Khaur, Attock district, Punjab (Lat. 33° 22′; Long. 72° 32′) by the second author, who subsequently carefully cleared the teeth from the rock matrix by which they had been largely obscured.

Stratigraphy and lithology of the beds.

The beds from which the specimen was obtained are not more than 5 miles distant from the type area of the Kamlial stage, in fact they form the southerly dipping limb of a syncline, the northerly dipping limb of which forms actually the northern side of the Khaur dome.[1] Lithologically they consist mainly of rather hard sandstones of a dark brick-red colour, interbedded with hard purple shales containing pseudo-conglomeratic bands of yellow and purple colours. Beds of this type attain a thickness of about 1,000 feet in this area. They are overlain by soft, grey sandstones and bright red shales, the latter forming the major part of the group. These beds are easily recognized as belonging to the Chinji stage, not only by their softer sandstones, but also by the fossils of Chinji species which they contain. The beds which underlie those in which the mandible was found, equally consist of soft grey sandstones with bright purple shales; these are scantily fossiliferous and may be referred to the Upper Murree stage.

Thus the beds of the Kamlial stage, to which our fossil specimen belongs, differ from both the overlying Chinjis and the underlying Upper Murrees by their much harder sandstones, which by reason of this character and their higher dips, at angles of from 60° to 80°, form strike ridges with an elevation above their base of from 300 to 400 feet; these ridges are a striking topographical feature of the

[1] Pilgrim, Preliminary note on some recent Mammal collections from the basal beds of the Siwaliks, *Rec. Geol. Surv. Ind.*, XLVIII, p. 98; Pinfold, Notes on structure and stratigraphy in the North-West Punjab. *Rec. Geol. Surv. Ind.*, XLIX, p. 154.

area and run between Sadrial and Pamra Jagir, a distance of roughly 10 miles south of and parallel to the Khaire Murat Ridge.

Additional fossil evidence.

Palaeontological evidence is not wanting that these beds belong to a distinctly older stage than those of Chinji, approximating in character both to those of the basal Manchhars of Sind and in a less degree to the Gaj beds of the Bugti Hills and the basal Murrees or Fatehjang stage of the Punjab. The following fossils were obtained either by the second author or by Mr. H. M. Lahiri from the same beds or from their continuation along the strike :—

Trilophodon cf. *angustidens*. (K. 23. 729.)
Dinotherium indicum.
Dinotherium sp., P_3 of a small species. (K. 33, 734.)
Amphicyon sp., m_2 of about the same size and shape as in *A. shahbazi*, but much corroded. (K. 23. 739.)
Hyaenaelurus sp., a large species in a more advanced stage of evolution than either *H. bugtiensis* or *H. sulzeri*. (K. D. 236.) (K. 23. 728.)
Anthracotherium sp., a mandible of a large species somewhat inferior in size to *A. bugtiense* or *A. ingens*, but with a much smaller canine and therefore probably belonging to a female; premolars elongate, p_2, 40 mm ; p_3 45·5 mm. ; diastema of 10 mm. between the canine and p_1, and of 30 mm. between p_1 and p_2.

Two fragmentary upper molars (K. 23. 735-6) probably belong to the same species; they are extraordinarily bunodont. Diameter across the hinder portion 41·5 mm.

Hemimeryx cf. *pusillus*, m_3. (K. 23. 730.)
Hemimeryx (?) *blanfordi*, fragmentary upper molar. (K. 23. 719.)
Listriodon pentapotamiae.

Description of the specimen.

The mandible now before us (Ind. Mus. B. 773) possesses the almost complete dentition on the left side, except that the two front incisors are missing and the greater part of the crown of the canine has been broken away. On the right side m_3, p_1, the canine and the incisors have lost their crowns entirely, and some of the other teeth are damaged. The space between the rami is still filled with matrix as well as most of the symphysis. The specimen is figured in Plate 20, and its dimensions together with those of the individual

teeth are given on page 203. The mandible belonged to an individual considerably past the age of maturity, and all the teeth, including m_3, show pronounced signs of wear.

As will be obvious from the figure, the mandible is that of a Suoid animal, while the simple conical shape and large size of the last two premolars enable it to be referred unhesitatingly to the genus *Conohyus* Pilgrim, of which the genotype is the species *C. simorrensis* (Lartet).[1]

Three Indian species of *Conohyus* have been described by Pilgrim in the memoir quoted above —(1) *C. chinjiensis*; (2) *C. sindiensis*; (3) *C. indicus*; and Stehlin[2] has referred all the European specimens to the single species *C. simorrensis*. Since the general structure of the teeth of the new specimen is essentially the same as that of previously described species of *Conohyus*, it does not seem necessary to describe them in detail. The differences mainly concern the relative size of the individual teeth, and these and such other trifling points, in which it appears to differ from other specimens will be commented upon in the course of our comparisons with the specimens in question.

Comparisons with Conohyus chinjiensis.

The only specimen of *C. chinjiensis* which shows both the three lower molars and the two last lower premolars is the type ramus (Ind. Mus. B. 537). The present mandible differs from this in regard to the length of m_3 relative to that of m_1 and m_2, m_3 being very distinctly shorter in the Kamlial species. P_4 closely resembles the corresponding tooth of *C. chinjiensis*, though it is very slightly longer on account of the more prominent posterior cusp. P_3 is very considerably longer in the Kamlial than in the Chinji species, the difference in length being correlated not only with the longer posterior cusp but also with the more gradual descent of the anterior keel from the summit to the base of the teeth.

The type ramus of *C. chinjiensis* is smaller than the majority of specimens of *Conohyus* from the Chinji stage, but since all these, with one possible exception, agree with it in regard to the relative length of m_3 and p_3, it may be assumed that these characters are constant for the species, and, therefore, will serve as a means of specific distinction from the new mandible.

[1] Pilgrim, The fossil Suidae of India, *Pal. Ind.*, N. S., Vol. VIII, Mem. 4, (1926.)

[2] Stehlin, Ueber die Geschichte des Suiden-Gebisses, *Abh. Schweiz Pal. Ges.* Vols. XXVI, XXVII, (1899 1900).

Unfortunately a comparison with the species *C. sindiensis* is difficult owing to the fact that the isolation of the lower molars and premolars in the case of all the specimens of *Conohyus* collected from the basal beds of the Lower Manchhars of Sind, leaves us in uncertainty not only as to the relative size of p_3 and m_3 in the species but even as to whether the isolated lower molars are referable to the genus *Conohyus* at all. Since, however, the specimens of p_3 from Sind are invariably longer and those of m_3 generally shorter than the corresponding teeth of *C. chinjiensis* from the Chinji stage of the Punjab, there is a greater likelihood that the absolute dimensions of these teeth approximately represents their relative size in the species, rather than that the premolars belong to large individuals and the molars to small individuals. If we may legitimately draw this inference from the material, then the species *C. sindiensis* and the present mandible differ from *C. chinjiensis* in a similar sort of way. A ramus from Sind (Ind. Mus. K. 19·59), containing m_3 and the roots of m_1, m_2 and the posterior root of p_3, shows very nearly the same proportions as in the new mandible.

Comparisons with Conohyus sindiensis.

The size of p_3 in the new mandible, however, exceeds that of all the Sind specimens of p_3.

The type and other specimens of *Conohyus indicus* from the Nagri stage are absolutely larger than the mandible now under consideration. Although p_3 of that species is no longer than the present one, yet it is considerably stouter, and both p_4 and m_3 are of considerably greater dimensions than the corresponding teeth in the mandible from Sadrial. In fact though *C. indicus* is much larger than *C. chinjiensis* yet in the relative dimensions of the individual teeth it stands nearer to that species than to *C. sindiensis* or to the present mandible.

Comparisons with Conohyus indicus.

The various figured specimens of the European *Conohyus*, all referred by Stehlin to the one species *C. simorrensis* vary considerably in regard to the relative dimensions of the teeth, but it cannot be regarded as certain that they should not be specifically differentiated. The length of both p_3 and p_4 often greatly exceed those of the same teeth in the Sadrial mandible although they are of a slighter build; moreover the anterior cusp in p_3 is much more

Comparisons with Conohyus simorrensis.

elevated above the base of the crown than in any Indian form including the present one. On the other hand m_3 relatively to m_1 and m_2 is generally larger than in the Sadrial form.

The two front premolars of the specimen.

For comparison with p_1 and p_2 we have only European material and little of this seems to have been figured. The present p_1 agrees in size with that figured by Hoffmann [1], but in our specimen, the profile of that portion of the tooth posterior to the main cusp is concave, instead of grading down along a straight profile to the hinder edge. P_2 exists in a specimen of *C. simorrensis* figured by Deperet [2]. It is somewhat shorter than p_4 but much shorter and with a much lower crown than p_3. The corresponding tooth in the present specimen is on the other hand rather longer than p_4 but as in the case of the European tooth it is much shorter, lower and slighter than p_3. It does not seem to differ in structure from the European tooth.

The lower canine of the specimen.

The base of the lower canine is well shown on the left side of the mandible. Owing to the enamel having perished at the hinder end of the tooth, the actual outline of the cross-section in that region is uncertain, so that the point at which the two longer sides of the triangle intersect cannot be precisely fixed. The tooth has, however, a strongly scrofic cross-section, which does not differ essentially from the cross-sections of *Conohyus simorrensis* figured by Stehlin [3]; An isolated specimen of the lower canine (Ind. Mus. B. 774) was obtained by the second author from the same beds. This measures 11 mm. along the curved edge. It is narrower than the canine of the mandible and its scrofic character is, therefore, even more strongly marked.

The third incisor of the specimen.

I_3, the only incisor present in the mandible, is much worn, so that its characters cannot be satisfactorily determined. It is an elongate, narrow tooth, which appears to have possessed a high, elongate anterior cusp, and a very low indefinite posterior cusp; the latter is flanked by a slight cingulum posteriorly. I am unable to compare it with the European *Conohyus*, as no specimen of that tooth has, so far as I am aware, been figured.

[1] Fauna von Goriach, Pl. XVI, fig. 3.
[2] *Archives Mus. Hist. Nat. Lyon*, Vol. IV, text fig. 5.
[3] Stehlin, *op. cit.*, Pl. VII, figs. 11, 12, 13.

In conclusion the distinctness of this mandible from *Conohyus chinjiensis* is evident. The inferiority in length of m_3 suggests that it is more primitive than the Chinji species, which from its stratigraphical position is not surprising. It resembles much more nearly *Conohyus sindiensis*, though it does not apparently agree exactly with that species but it differs even more widely from *Conohyus simorrensis*. In view of the fact that there is some reason to suppose that the distinctive characters vary individually to some extent, and considering the probability that the beds at Sadrial from which the mandible came are of the same horizon as those of Sind, whence the specimens of *Conohyus sindiensis* were obtained, it does not seem advisable to separate it specifically from the Sind species.

Conclusions as to the specific position of the specimen.

The greatest value of the present find lies in the evidence it affords that the Indian species of *Conohyus* possessed a lower canine which was no less "scrofic" than its European congener. Its cross section is especially striking when it is compared with that of the lower canines of most other fossil Indian Suidae of contemporary and later ages; Up to the Dhok Pathan stage, believed to correspond to the Pontian, these have lower canines of a verrucose or at any rate only sub-scrofic type.[1] This supplies the final proof, if such were needed, that the European *Conohyus simorrensis* is generically the same as the Indian species.

Importance of the scrofic character of the canine.

Further importance attaches to the discovery in the bearing it has on the origin of the curious genus *Tetraconodon*. The alliance of that genus to *Conohyus*, first asserted by Stehlin, was confirmed by Pilgrim's later discoveries. It was, therefore, confidently expected that the lower canine of *Tetraconodon* when found would prove to be of a scrofic type. The recent discovery by Mr. A. E. Day of a mandibular ramus of *Tetraconodon minor*, containing the canine,[2] only partially fulfilled this expectation. The lower canine was scrofic but much less so than that of *Conohyus simorrensis*. Accepting, as Pilgrim did, the hypothesis that the "scrofic" type of canine had gradually evolved out of the

Its bearing on the origin of the genus Tetroconodon.

[1] Pilgrim, The Fossil Suidae of India, *Pal. Ind.*, N. S., Vol. VIII, Mem. No. 4, (1926).

[2] Pilgrim, The lower canine of Tetraconodon, *Rec. Geol. Surv. Ind.*, LX, p. 162, (1927).

"verrucose" type, it was obvious that the canine of *Tetraconodon* must have arisen out of a verrucose or sub-scrofic type, and, therefore, *Conohyus simorrensis* could not have been its ancester. To explain the anomaly Pilgrim suggested two alternative suppositions :—

(1) that the Indian species of *Conohyus* were less progressive than the European *C. simorrensis* in respect of the evolution of the canine;

(2) that *Tetraconodon* was derived from an older and more primitive form than any known species of *Conohyus*.

It cannot be said that the new find entirely disposes of the first possibility since any one of the other two species of *Conohyus* might conceivably have verrucose canines. It, however, renders the second alternative by far the most likely. In this case *Tetraconodon* is probably a migrant from an as yet unknown developmental centre, where the common ancestor of *Conohyus* and *Tetraconodon* alike, having verrucose canines, was evolved. In support of this may be urged the fact that no species quite intermediate between *Tetraconodon* and *Conohyus* has as yet been found in India, and also the existence of another genus in the Dhok Pathan stage. *Sivachoerus*, which also has somewhat enlarged p_3 and p_4 with a strongly verrucose lower canine.

EXPLANATION OF PLATE.

FIG. 1.—*Conohyus* cf. *sindiensis* (Lyd.) Mandible from the Kamlial stage of Sadrial near Khaur, Attock district, Punjab.(Ind. Mus. B.773) surface view; natural size.

FIG. 2.—Inner side, view of the left hand series of teeth in the same mandible; natural size.

FIG. 3.—Cross-section of the canine in the same mandible; natural size.

Measurements of Specimens of Conohyus

Name of species.	P_1 Ant.-Post.	P_1 Transverse.	P_2 Ant.-Post.	P_2 Transverse.	P_3 Ant.-Post.	P_3 Transverse.	P_4 Ant.-Post.	P_4 Transverse.	M_1 Ant.-Post.	M_1 Transverse.	M_2 Ant.-Post.	M_2 Transverse.	M_3 Ant.-Post.	M_3 Transverse.	REMARKS. $\frac{m_3}{m_1+m_2}$	$\frac{p_3}{m_1}$	$\frac{p_3}{m_3}$	$\frac{p_3}{p_4}$
Conohyus cf. sindiensis Lyd., Ind. Mus. No. B. 773.	13·4	5·5	16·0	8·3	23·2	14·9	15·5	14·0	13·6	11·3	15·0	13·5	20·4	13·5	·71	1·70	1·14	1·50
[1] Conohyus sindiensis Lyd., Ind. Mus. No. B. 668.	..	..	..	..	19·6	12·5	..	..	..	..	..	..	..	..	..	..	..	..
[2] Conohyus sindiensis Lyd. Ind. Mus. B. 670.	..	..	..	..	..	..	18·3	16·5	..	..	..	..	..	..	..	..	..	..
Conohyus sindiensis Lyd. Ind. Mus. No. B. 99(*a*).	..	..	..	..	..	..	..	..	..		..	..	22·5	13·5	..	..	..	..
[3] Conohyus sindiensis Lyd. Ind. Mus. No. 667.	..	..	..	..	..	..	19·0	14·0	..	..	..	..	..	..	..	..	..	..
Conohyus sindiensis Lyd. Ind. Mus. No. K. 19/59.	..	..	..	..	..	..	..	..	app. 13·8	app. 11·0	app. 14·9	app. 13·4	20·9	13·1	·72	..	1·00	..
Conohyus sindiensis Lyd. Ind. Mus. No. K. 10/60.	..	..	..	..	22·3	14·5	..	..	..	..	..	..	..	..	..	..	..	..

[1] *Pal. Ind.*, N. Ser., Vol. VIII, Mem. 4, pl. 2, fig. 2.
[2] *Pal. Ind.*, N. Ser. Vol. VIII, Mem. 4, Pl. 2, fig. 4.
[3] *Pal. Ind.*, N. Ser., Vol. VIII, Mem. 4, pl. 2, fig. 1.

Measurements of Specimens of Conohyus—contd.

Name of species.	P_1. Ant.-Post.	P_1. Transverse.	P_2. Ant.-Post.	P_2. Transverse.	P_3. Ant.-Post.	P_3. Transverse.	P_4. Ant.-Post.	P_4. Transverse.	M_1. Ant.-Post.	M_1. Transverse.	M_2. Ant.-Post.	M_2. Transverse.	M_3. Ant.-Post.	M_3. Transverse.	$\frac{m_3}{m_1+m_2}$	$\frac{p_3}{m_1}$	$\frac{p_4}{m_1}$	$\frac{p_3}{p_4}$
															REMARKS.			
Conohyus chinjiensis Pilg. Ind. Mus. No. K. 15/518.	..	..	..	..	20·0	13·3	16·9	14·9	15·0	13·0	..	..	..	..	..	1·33	..	1·20
* Conohyus chinjiensis Ind. Mus. No. B. 537.	..	..	..	..	18·8	13·8	13·6	14·5	12·3	11·4	15·6	13·9	22·3	13·9	·89	1·51	1·10	1·39
Conohyus chinjiensis Pilg. Ind. Mus. No. K. 13/816.	..	..	..	..	..	..	14·6	15·0	16·0	12·8	16·9	14·6	24·0	4· 14	·705	..	8·0	..
Conchyus chinjiensis* Pilg. Ind. Mus. No. K. 13/825.	..	..	..	..	..	..	15·2	11·8	13·7	12·0	15·8	14·0	21·5	13·2	·72	..	1·10	..
Conohyus chinjiensis Pilg. Ind. Mus. No. K. 15-518.	..	..	..	..	20·0	13·3	16·9	14·0	15·0	13·0	..	..	..	..	..	1·33	1·12	1·20
Conohyus chinjiensis Pilg.	..	..	..	..	..	..	15·0	14·8	14·4	13"2	18·0	14·4	..	..	..	..	1·10	..
Conohyus chinjiensis† Pilg. Ind. Mus. No. K. 14-491.	..	..	..	..	..	..	16·5	12·9	18·5	11·5	16·3	14·5	..	..	..	..	·91	..

[5] Conohyus indicus (Lyd.) Ind. Mus. No. B. 553.	..	..	..	..	19·0	18·7	22·5	18·0	..	..	..	..	24·2	15·2	..	..	..	..
[6] (*a*) Conohyus simorrensis (Lartet).	..	..	..	..	25·0	16·4	18·4	15·3	16·1	..	18·0	14·1	24·4	14·2	·715	1·55	1·14	..
[7] (*b*) Ditto ditto	..	..	..	..	..	..	16·2	12·4	15·8	12·0	16·6	18·7	22·6	14·8	·69	..	..	..
[8] (*c*) Ditto ditto**	..	..	15·5	..	19·0	..	15·5	..	18·0	..	20·0	..	26·0	..	·68	..	..	..
[9] (*d*) Ditto ditto	13·3	5·6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
[10] (*e*) Ditto ditto*	18·0	..	26·0	..	20·0	..	17·3	..	..	..	..	..	..	..	..	..	..	..
[11] (*f*) Ditto ditto	..	..	..	..	25·0	15·0	19·0	15·4	..	..	..	..	27·5	14·0	..	..	..	..

Measurements of Canine root—
Ant. = 7·6.
Post = 10·9.
Int. = 11·4'.
Incisor:—Ant.-Post 98.
Transverse = 41.

Measurements of P_4 approximate.
*m_1 much worn out.
†M_2 very imperfect.
**Measurements from figures.

[4] *Pal. Ind.*, N. Ser., Vol. VII, Mem.[1], pl. 2, fig. 10.
[5] „ „ „ „ „ „ 8.
[6] *Abh. K. K. Geol. Reich.*, Vol. XVI, pl. 16, fig. 1.
[7] „ „ „ „ „ 2.
[8] *Jahr. Nat. Wurtt.* 1869—70, pl. VIII, fig. 1.
[9] *Abh. K. K. Geol. Reich.*, Vol. XVI, pl. 16, fig. 3.
[10] *Arch. Mus. Hist. Nat. Lyon.*, Vol. IV, pl. XIII, figs. 26 &27, and p. 240, fig. 5.
[11] *Abh. Schw. Pal. Ges.*, Vol. XXVII, pl. 1, figs. 9, 20, and 21.

MISCELLANEOUS NOTE.

Leucopyrite from Kodarma.

A specimen forwarded through Dr. C. S. Fox to this department by Messrs. F. F. Chrestien & Co., Ltd., has been identified as leucopyrite, a variety of löllingite. The mineral occurred on the schist foot-wall at the contact between pegmatite and schist at a depth of 150 feet in the above-mentioned company's Gamaria mine, in the Khalaktambi division of Kodarma forest.

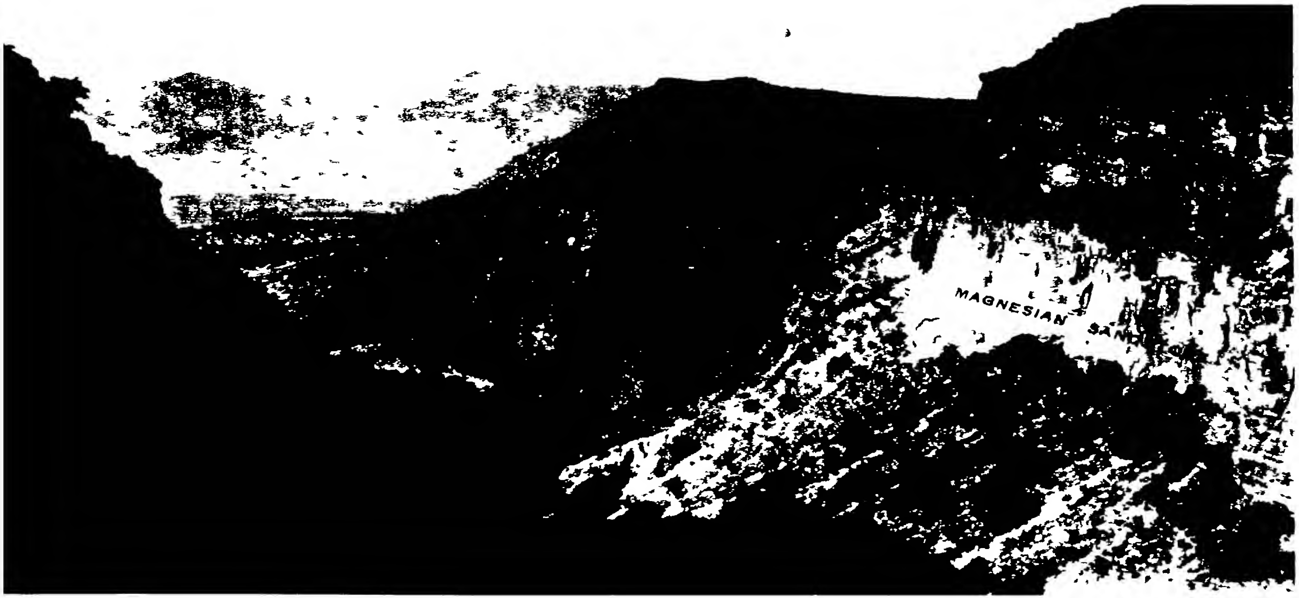
Qualitative tests showed the presence of abundant arsenic and iron and a little sulphur; no bismuth, cobalt or nickel could be detected, but traces of antimony were found.

The specific gravity of material free from quartz and muscovite, which minerals are associated with the mineral in question, was determined as 7·02 Dana gives the specific gravity of the varieties of lollingite distinguished as lollingite and leucopyrite as 7·234 and 7·0—7·2, respectively; accordingly, though no chemical analysis is available, the mineral has been provisionally identified as the variety leucopyrite and registered under that name as M-978 in the collections of this department.

Leucopyrite has previously been recorded from the Behar mica belt, (See *Rec. Geol. Surv. Ind.*, VII, 1, 1874, p. 43, and *Mem. Geol. Surv. Ind.*, XXXIV, 2, 1902, p 51.)

A. L. COULSON.

MGIPC—M—VIII-4-3—14-9-28—800.



C. S Fox, Photo

G S I Calcutta

VIEW OF THE JUTANA CANYON FROM THE HEAD OF THE FALLS

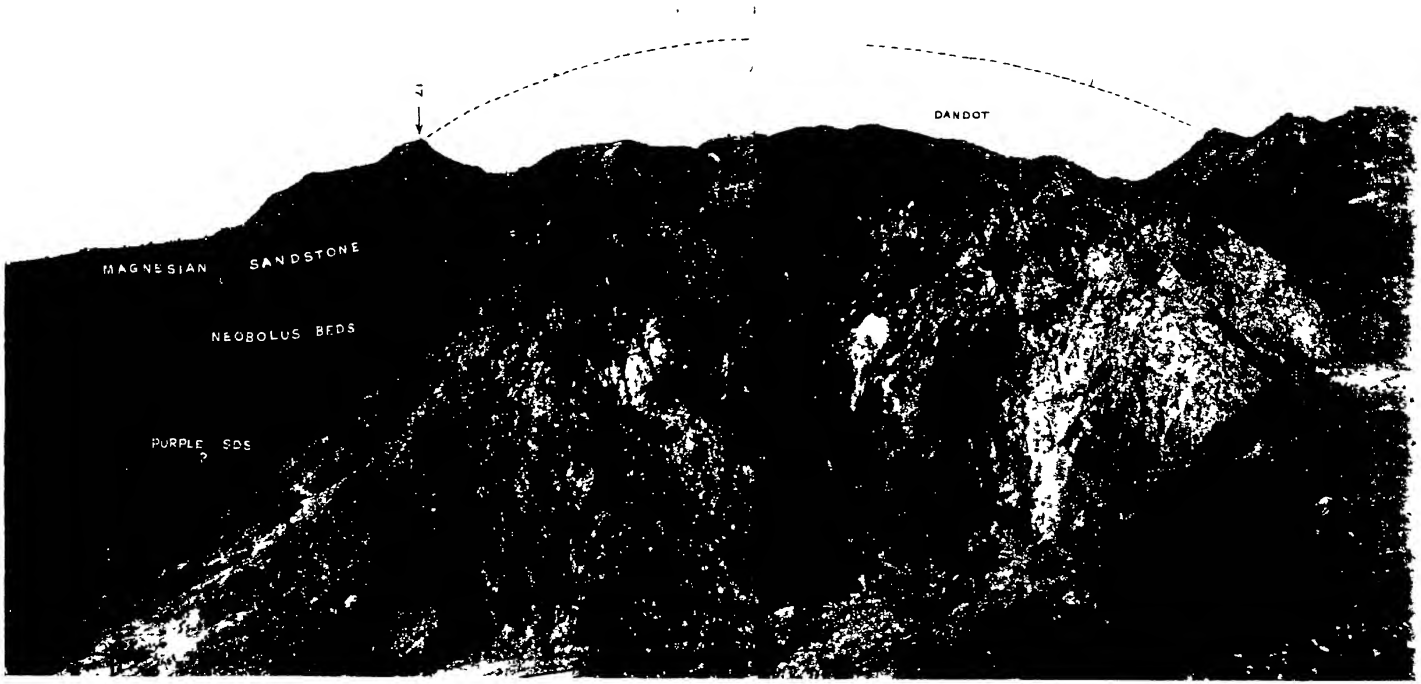
C S Fox, Photo

G S I Calcutta

VIEW OF KHEWRA GORGE AND VILLAGE

M S—Magnesian Sandstone N B—Neobolus Beds P S Purple Sandstone

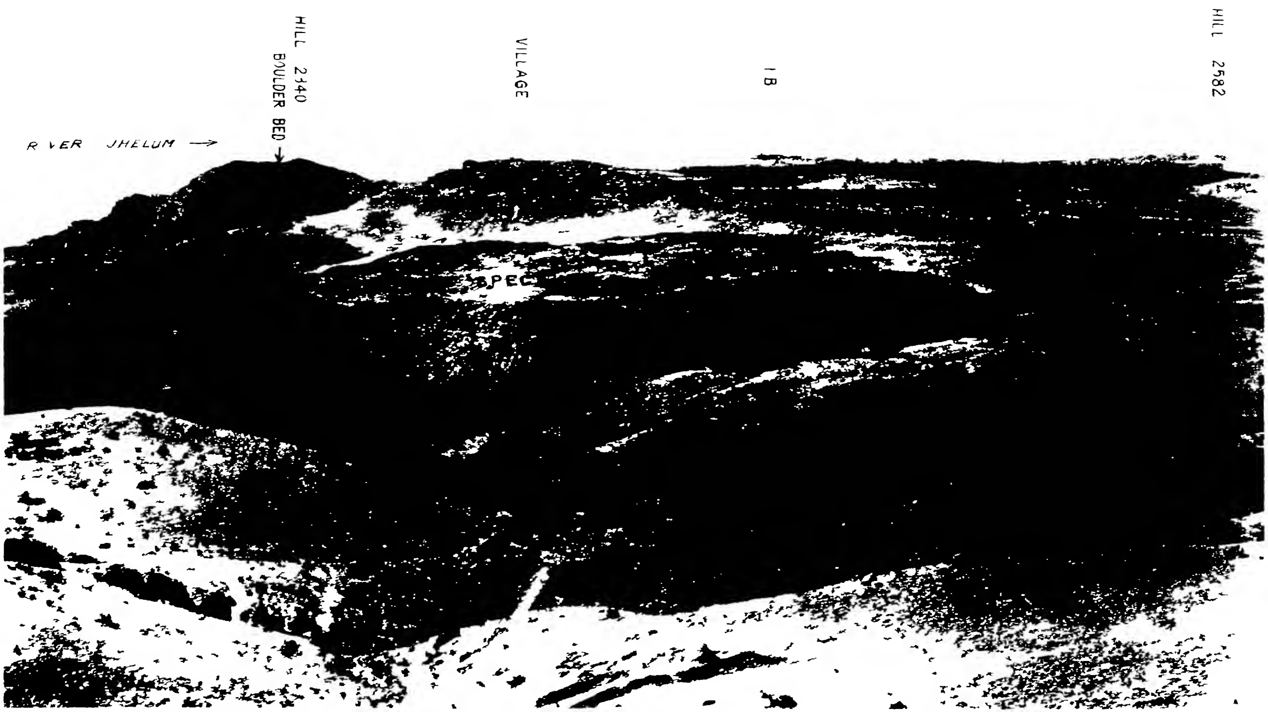
Records, Vol LXI, Pl. 4.



C. S. Fox, Photo.

G. S. I Calcutta

VIEW LOOKING WEST FROM THE EAST SIDE OF THE KHEWRA GLEN

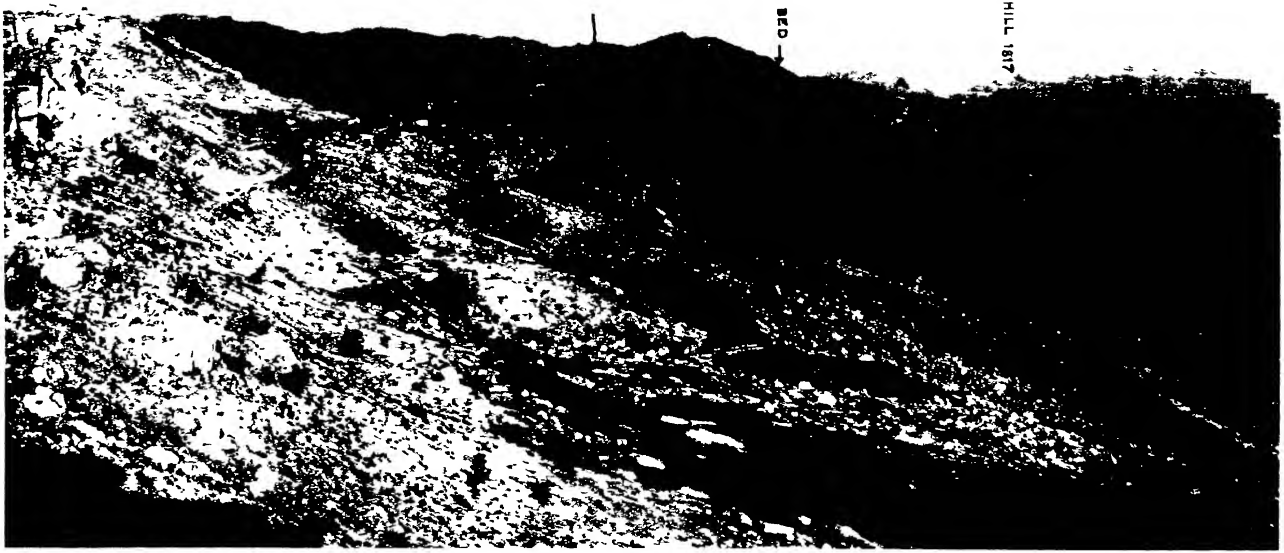


C S Fox, Photo

G S I Calcutta

VIEW OF DANDOT PLATEAU, FROM HILL 2666 SOUTH OF PIDH

S P B —Salt Pseudomorph Beds M S —Magnesian Sandstone N B —Neobolus Beds P S —Purple Sandstone

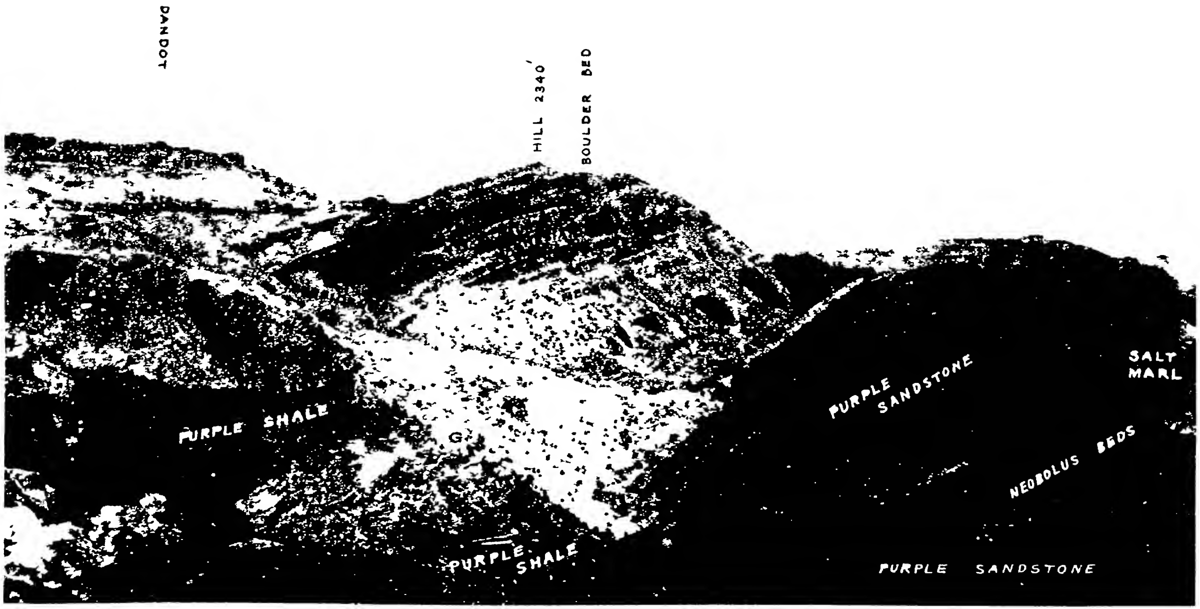


C. S. F x Photo. *G S. I. Cal utta*

VIEW FROM DANDOT PLATEAU LOOKING SOUTH-EA T.

A—Salt marl near Khewra B—Salt Pseudomorph beds G Gypsum band M S—Magnesia n sandstcnes

Records, Vol. LXI, Pl 8.



C S Fox Photo.

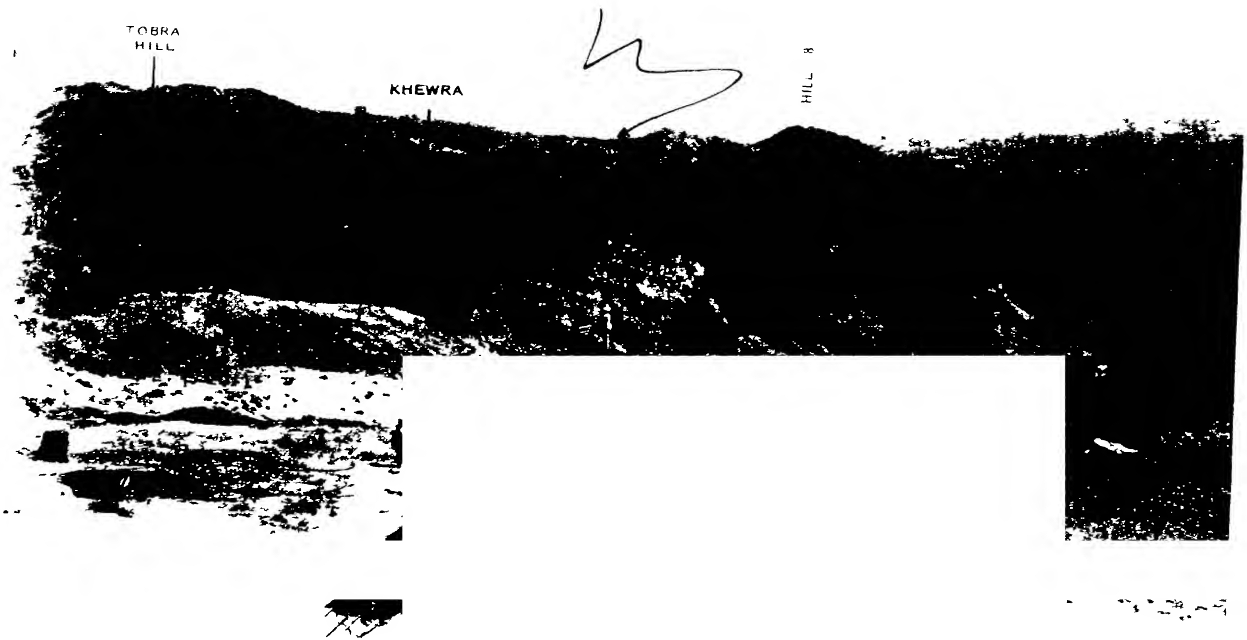
G S I Calcutta

VIEW LOOKING EASTWARD FROM HILL 2061

Records, Vol LXI, Pl 9

C. S Fox, Photo. G S I Calcutta

CONTINUATION OF THE DANDOT SECTION, ALSO TAKEN FROM HILL 2061
LOOKING EASTWARD.

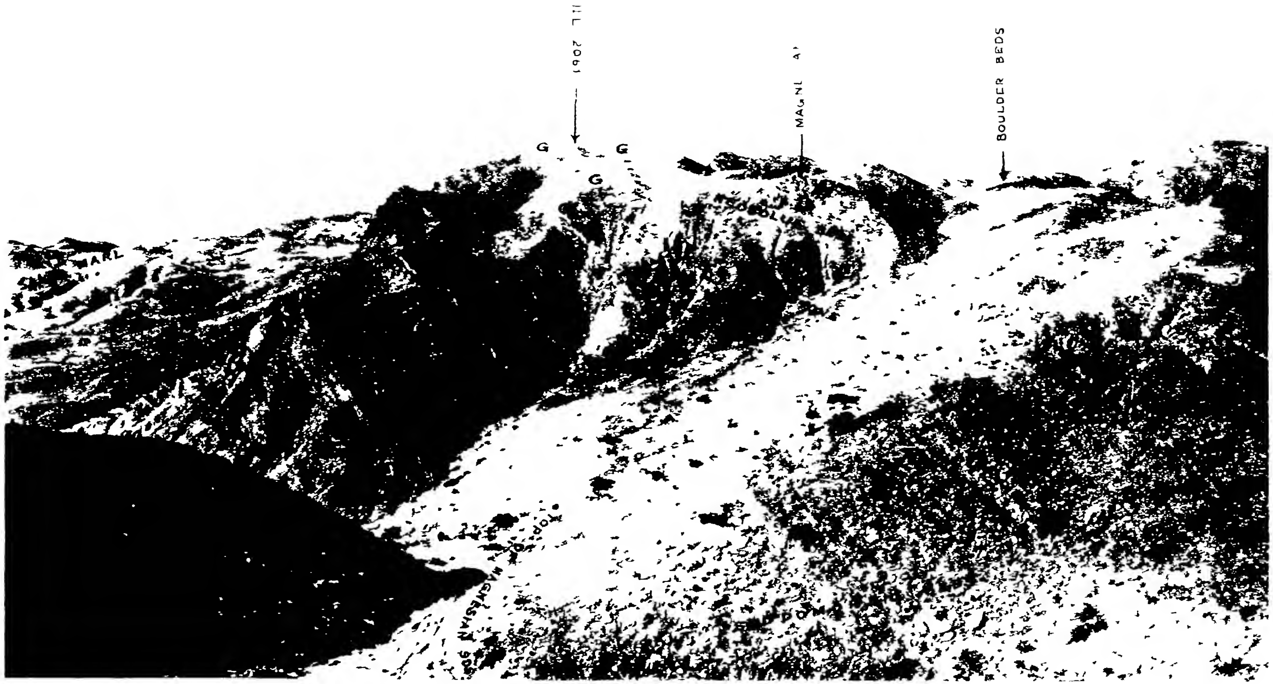


C S Fox Photo

G S I Calcutta

VIEW LOOKING E S E FROM THE SADDLE BETWEEN HILL 2340 AND DANDOT VILLAGE

M S—Magnesian Sandstone

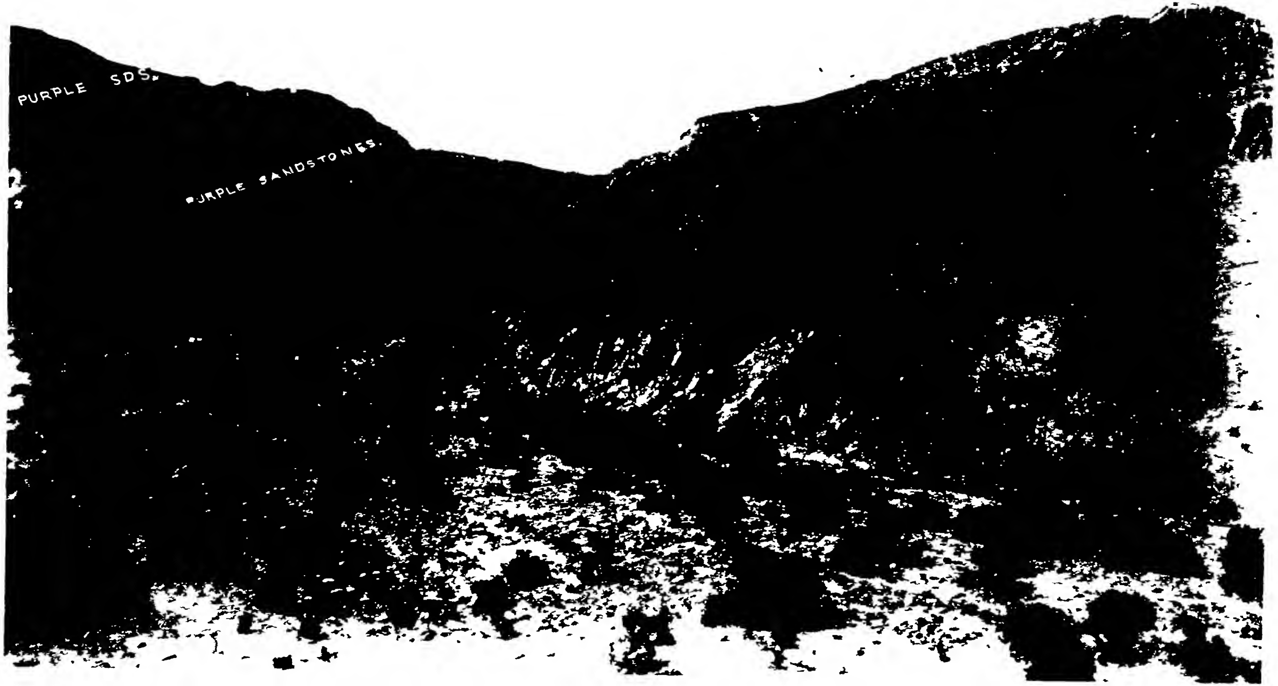


C S Fox, Photo. G S I Calcutta

VIEW FROM BELOW THE SUMMIT OF HILL 2340, SOUTH OF DANDOT LOOKING WESTWARD

Murray Stuart, Photo. *G. S. I. Calcutta*

BANDED ROCK-SALT IN THE NILAWAN RAVINE



Murray Stuart, Photo

G S I Calcutta

VIEW LOOKING UP THE NILAWAN RAVINE

D O, G. S I, Photo. *G. S I Calcutta.*

PSEUDOMORPHS OF CLAY AFTER ROCK-SALT

C. S Fox Photo *G S I. Calcutta*

THE SALT HILL OF BAHADUR KHEL (KOHAT DISTRICT)

C S. Fox Photo.

G. S. I. Calcutta

Murray Stuart, Photo. *G. S. I. Calcutta.*

VIEW LOOKING SOUTH DOWN THE NILAWAN RAVINE.

S. N. Guine, del *G. S I Calcutta.*

CONOHYUS *cf.* SINDIENSIS (Lyd).

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1928 [September

THE MINERAL PRODUCTION OF INDIA DURING 1927. BY L. L. FERMOR, O.B.E., A.R.S.M., D.Sc., F.G.S., M. INST. M.M., *Officiating Director, Geological Survey of India.*

CONTENTS.

I.—INTRODUCTION.

THE method of classification adopted in the first Review of Mineral Production published in these Records (Vol. XXXII, 1905), although admittedly not entirely satisfactory, is still the best that can be devised under present conditions. As the methods of

collecting the returns become more precise and the machinery employed for the purpose more efficient, the number of minerals included in Class I—for which approximately trustworthy annual returns are available—increases, and it is hoped that the minerals of Class II—for which regularly recurring and full particulars cannot be procured—will in time be reduced to a very small number. In the case of minerals still exploited chiefly by primitive Indian methods, and thus forming the basis of an industry carried on by a large number of persons, each working independently and on a very small scale, the collection of reliable statistics is impossible; the total error from year to year is, however, not improbably approximately constant and the figures obtained may be accepted as a fairly reliable index to the general trend of the industry. In the case of gold, the small indigenous alluvial industry contributes such an insignificant portion to the total outturn that any error from this source may be regarded as negligible.

The average value of the Indian rupee during the year 1927 was 1*s.* $5\frac{29}{32}$*d.*; the highest value reached was 1*s.* $6\frac{3}{32}$*d.*, and the lowest 1*s.* $5\frac{13}{16}$*d.* The values shown in Table 1 and all following tables of the present Review are given on the basis of 1*s.* $5\frac{15}{16}$*d.* to the rupee for 1926 and 1*s.* $5\frac{29}{32}$*d.* to the rupee for 1927, the latter ratio being taken for ease of calculation as equivalent to Rs. 13·4 to £1, instead of Rs. 13·403.

From Table 1 it will be seen that there has been a decrease of over £2,899,000 or about 11·2 per cent. in the value of the total production over that of 1926. An increase or decrease in value does not always correspond to a similar variation in output, and cannot, therefore, be regarded as an infallible indication of the state of an industry. It must be understood that the figures of Table 1 are value figures and that a decrease does not necessarily mean a reduced output or a decline in the industry. For instance, in the cases of coal, lead, and silver, production increased substantially and the reduced value figures are due to a drop in the market price. Practically the whole of the decrease is, however, due to an enormous fall in the value of the petroleum output, the quantity of which increased slightly.

The number of mineral concessions granted during the year amounted to 714 against 758 in the preceding year; of these two were exploring licenses, 603 were prospecting licenses and 109 were mining leases.

TABLE 1.—*Total Value of Minerals for which returns of production are available for the years 1926 and 1927.*

——	1926. (£1= Rs. 13·4.)	1927. (£1= Rs. 13·4.)	Increase.	Decrease.	Variation per cent.
	£	£	£	£	
Coal	7,574,599	7,079,852	..	494,747	—6·4
Petroleum	7,305,509	4,421,468	..	2,884,041	—39·5
Manganese-ore (*a*)	2,590,357	2,844,237	253,880	..	+9·5
Lead and lead-ore	1,666,587	1,641,095	..	25,492	—1·5
Gold	(*c*)1,624,238	1,626,913	2,675	..	+0·2
Building materials	860,558	914,187	53,629	..	+6·2
Salt	836,830	849,265	12,435	..	+1·5
Silver	663,063	708,846	45,783	..	+6·9
Mica (*b*)	820,901	691,341	..	129,560	—15·8
Zinc-ore (*b*)	321,177	522,737	201,560	..	+62·8
Tin and tin-ore	455,362	493,864	38,502	..	+8·4
Iron-ore	349,676	380,735	31,059	..	+8·8
Copper-ore and matte	362,566	344,299	..	18,267	—5·0
Saltpetre (*b*)	98,846	113,632	14,786	..	+14·9
Chromite	30,810	65,743	34,933	..	+113·4
Tungsten-ore	57,535	42,537	..	14,998	—26·1
Ilmenite	7,587	33,443	25,856	..	+340·8
Jadeite (*b*)	35,091	22,570	..	12,521	—35·6
Ruby, sapphire and spinel.	34,834	20,883	..	13,951	—40·0
Clays	32,807	19,819	..	12,988	—39·6
Magnesite	26,444	17,115	..	9,329	—35·3
Nickel speiss	..	10,073	10,073	..	..
Antimonial lead	23,918	9,930	..	13,988	—58·5
Zircon	2,987	8,129	5,142	..	+172·1
Steatite	11,213	7,816	..	3,397	—30·3
Gypsum	(*c*)5,929	6,702	773	..	+13·0
Monazite	947	3,810	2,863	..	+302·3
Diamonds	2,131	3,354	1,223	..	+57·4
Bauxite	2,744	2,107	..	637	—23·2
Ochre	(*c*)2,252	2,051	..	201	—8·9
Amber	1,599	2,028	429	..	+26·8
Refractory materials	1,624	2,025	401	..	+24·7
Alum	3,761	1,728	..	2,033	—54·5
Fuller's earth	1,761	1,687	..	74	—4·2
Asbestos	786	1,011	225	..	+28·7
Antimony-ore	201	784	583	..	+290·0
Apatite	804	750	..	54	—6·7
Barytes	690	738	48	..	+7·0
Corundum	342	598	256	..	+74·8
Soda	285	33	..	252	—88·4
Bismuth	..	10	10	..	..
Borax	2	1	..	1	—50·0
Copperas	2	1	..	1	—50·0
Beryl	7	..	..	7	..
Serpentine	3	..	..	3	..
Total	**25,819,365**	**22,919,947**	737,124	3,636,542	—*11·2*
			$\underbrace{\qquad\qquad\qquad}_{\textbf{—2,899,418}}$		

(*a*) Value f.o.b. (*b*) Export values. (*c*) Revised.

II.—MINERALS OF GROUP I.

Antimony.

Antimonial lead is obtained as a bye-product in the lead refinery at the Namtu smelter of the Burma Corporation Limited. This product contains approximately 77 per cent. of lead, 21 per cent. of antimony and 6 to 8 ozs. of silver to the ton, and is exported to the United States of America for further treatment. The output of antimonial lead was 1,057 tons valued at Rs. 3,20,500 (£23,918) in 1926 and 503 tons valued at Rs. 1,33,065 (£9,930) in 1927.

There is also a small production of antimony-ore in the Amherst district, Burma, which rose from 108 tons valued at Rs. 2,688 (£201) in 1926 to 500 tons valued at Rs. 10,500 (£784) in 1927.

Chromite.

The production of chromite in India during 1927, showed the large increase of 23,825 tons to a total of 57,207 tons. For this increase the Hassan district, Mysore, was chiefly responsible. The total exports from India during the year amounted, however, only to 42,953 tons, with resultant accumulation of stocks. Chromite exported from the ports in British India amounted to 20,996 tons against 29,614 tons in 1926. Chromite mined in British India is also exported from the port of Mormugao in Portuguese India; the quantities exported during 1926 and 1927 were 10,337 tons and 21,957 tons respectively. This increased production accompanied an increase in the value per ton of chromite produced from Rs. 12·4 in 1926 to Rs. 15·4 in 1927.

TABLE 2.—*Quantity and value of Chromite produced in India during the years 1926 and 1927.*

——	1926.			1927.		
	Quantity.	Value. (£1=Rs. 13·4.)		Quantity.	Value. (£1=Rs. 13·4.)	
	Tons.	Rs.	£	Tons.	Rs.	£
Baluchistan— Zhob . .	14,832	2,17,715	16,247	14,534	2,18,014	16,270
Bihar and Orissa— Singhbhum .	1,623	37,028	2,763	2,552	49,431	3,689
Mysore State— Hassan .	10,827	97,116	7,248	34,030	4,88,076	36,423
Mysore .	6,100	61,000	4,552	6,091	1,25,436	9,361
Total .	*33,382*	*4,12,859*	*30,810*	*57,207*	*8,80,957*	*65,743*

Coal.

There was a substantial increase during the year of 1,083,169 tons, or about 5·16 per cent., in the output of coal. This increase was due chiefly to Bengal, Bihar and Orissa, and to a lesser extent to Hyderabad, the Central Provinces and Assam, with a trivial increase in Central India. There was a decrease in the production of Rajputana, the Punjab and Baluchistan. The increase in Bengal was from the Raniganj field, and in Bihar and Orissa mostly from the Bokaro, Karanpura and Giridih fields. Bokaro now produces over 8 per cent. of the Indian product. Giridih again increased her raisings, the increase amounting to some 36,000 tons, while Karanpura jumped from a production of 123,867 tons in 1926 to over 262,000 tons in the year under review. Jharia showed a small proportionate increase of some 210,000 tons, and the output from Talchir again increased. There was a small initial production from Hutar. On the other hand, there were decreases in the output of Jainti, Daltonganj, Rampur and Ramgarh. In Central India, Sohagpur again failed to continue its former upward tendency and showed a further decline of some 26,000 tons. In the Central Provinces there was a substantial increase in the case of Pench Valley, and a smaller increase in the case of Ballarpur; the output of the Pench Valley was the highest yet recorded. For the increase in Hyderabad, Singareni was responsible, as the Sasti output fell by some 2,500 tons. All the Tertiary fields of Assam showed a moderate proportionate increase. In Baluchistan the Khost field continued its decline and the output dwindled to some 1,700 tons. The output from two of the three districts of the Punjab declined, whilst that of the third, Shahpur, increased. The Bikanir field of Rajputana showed a marked decrease in output.

In spite of the considerable increase in production during 1927 the statistical position at the end of the year was healthier than at the commencement, for stocks in the six provinces, Assam, Baluchistan, Bengal, Bihar and Orissa, the Central Provinces and the Punjab, for which such figures are available, showed a total reduction of 382,876 tons, as is seen from the following data:—

Year.	Opening stock.	Closing stock.	Reduction during year.
	Tons.	Tons.	Tons.
1926	2,660,062	2,161,806	498,256
1927	2,161,806	1,778,930	382 876

The reduction in stocks was shared by all provinces except Assam, which showed a trivial increase from 43 to 125 tons.

The total value of the coal produced in India decreased from Rs. 10,14,99,634 (£7,574,599) in 1926 to Rs. 9,48,70,013 (£7,079,852) in 1927.

There was a further reduction in the pit's mouth value per ton of coal for India as a whole from Rs. 4-13-4 to Rs. 4-4-9, but in contrast to the previous year all provinces did not participate in this fall. In the two great coal provinces Bihar and Orissa and Bengal, the value dropped by Rs. 0-9-7 and Rs. 0-12-7 respectively. In the Central Provinces it fell by Rs. 0-13-7; in Central India the fall was Rs. 0-2-10, and in the Punjab Rs. 0-2-3. The maximum fall, Rs. 1-1-1, was again in Baluchistan. These reductions are on a much smaller scale than those recorded in the two previous Reviews, and may perhaps indicate that the bottom of the market is being reached, especially if one correlates this fact with the additional fact that there has been an increase in output. In addition, three provinces show an increase, namely, Assam Rs. 4-13-10, Hyderabad Rs. 0-4-10 and Rajputana Rs. 0-10-7. This large increase in the value of the Assam coal is misleading, however. It appears that the value of the output of the Lakhimpur district has been seriously underestimated in pevious years, revised figures for which have not yet been obtained.

TABLE 3.—*Provincial Production of Coal during the years 1926 and 1927.*

Province.	1926.	1927.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Assam	301,061	323,342	22,281	..
Baluchistan	15,586	14,444	..	1,142
Bengal	5,137,688	5,554,990	417,302	..
Bihar and Orissa	13,955,775	14,517,866	562,091	..
Central India	216,708	217,661	953	..
Central Provinces	635,252	666,758	31,506	..
Hyderabad	637,779	707,213	69,434	..
Punjab	68,043	62,704	..	5,339
Rajputana	31,275	17,358	..	13,917
Total	**20,999,167**	**22,082,336**	***1,103,567***	***20,398***

TABLE 4.—*Value of Coal produced in India during the years 1926 and 1927.*

—	1926.			1927.		
	Value (£1 = Rs. 13·4.)		Value per ton.	Value (£1 = Rs. 13·4.)		Value per ton.
	Rs.	£	Rs. A. P.	Rs.	£	Rs. A. P.
Assam	23,66,774	176,625	7 13 9	41,18,400	306,970	12 11 7
Baluchistan . . .	1,47,463	11,004	9 7 5	1,21,255	9,049	8 6 4
Bengal	2,68,41,822	2,003,121	5 3 7	2,46,54,598	1,839,895	4 7 0
Bihar and Orissa . .	6,41,08,037	4,784,182	4 9 6	5,79,61,693	4,325,500	3 15 11
Central India . .	9,89,465	73,841	4 9 1	9,55,849	71,332	4 6 3
Central Provinces . .	33,41,762	249,385	5 4 2	29,40,268	219,423	4 6 7
Hyderabad (*a*) . .	30,12,893	224,843	4 11 7	35,54,461	265,258	5 0 5
Punjab	4,96,438	37,047	7 4 9	4,48,791	33,492	7 2 6
Rajputana	1,94,980	14,551	6 3 9	1,19,698	8,933	6 14 4
Total .	10,14,99,6[illegible]4	[illegible] 574,599	..	9,48,70,013	7,079,852	..
Average . .	..	..	*4 13 4*	..	..	*4 4 9*

(*a*) Estimated.

TABLE 5.—*Origin of Indian Coal raised during 1926 and 1927.*

—	Average of last five years.	1926.	1927.
	Tons.	Tons.	Tons.
Gondwana Coalfields	19,893,025	20,583,202	21,664,488
Tertiary Coalfields	456,114	415,965	417,848
Total .	20,349,139	20,999,167	22,082,336

TABLE 6.—*Output of Gondwana Coalfields for the years 1926 and 1927.*

Coalfields.	1926. Tons.	1926. Per cent. of Indian Total.	1927. Tons.	1927. Per cent. of Indian Total.
Bengal, Bihar and Orissa—				
Bokaro	1,514,918	7·21	1,790,594	8·11
Daltonganj	9,757	0·05	..	..
Giridih	818,681	3·90	855,253	3·87
Hutar	..	..	709	..
Jainti	82,604	0·39	56,724	0·26
Jharia	10,373,736	49·40	10,583,487	47·93
Karanpura	123,867	0·59	262,014	1·19
Rajmahal Hills	1,788	0·01	1,488	0·01
Ramgarh	585	..	340	..
Rampur (Raigarh-Hingir)	29,272	0·14	26,895	0·12
Raniganj	6,124,884	29·17	6,472,036	29·31
Talchir	13,371	0·07	23,316	0·10
Central India—				
Sohagpur	108,599	0·52	82,541	0·37
Umaria	108,109	0·51	135,120	0·61
Central Provinces—				
Ballarpur	142,935	0·68	158,617	0·72
Mohpani	71,482	0·34	..	..
Pench Valley	416,708	1·98	505,913	2·29
Shahpur	423	..	6	..
Yeotmal	3,704	0·02	2,222	0·01
Hyderabad—				
Sasti	28,034	0·14	25,477	0·12
Singareni	609,745	2·90	681,736	3·09
Total	**20,583,202**	*98·02*	**21,664,488**	*98·11*

TABLE 7.—*Output of Tertiary Coalfields for the years 1926 and 1927.*

—	1926. Tons.	1926. Per cent. of Indian Total.	1927. Tons.	1927. Per cent. of Indian Total.
Assam—				
Khasi and Jaintia Hills	555	1·43	825	1·46
Makum	255,189		271,220	
Naga Hills	45,317		51,297	
Baluchistan—				
Khost	3,545	0·07	1,734	0·07
Sor Range, Mach, Kalat	12,041		12,710	
Punjab—				
Jhelum	46,961	0·33	39,545	0·28
Mianwali	15,644		15,488	
Shahpur	5,438		7,671	
Rajputana—				
Bikanir	31,275	0·15	17,358	0·08
Total	**415,965**	*1·98*	**417,848**	*1·89*

The export statistics for coal during 1927 show a small decrease amounting to some 43,000 tons, the total exports of coal and coke falling from 617,563 to 576,167 tons, 2,510 tons of the latter being coke (*see* Table 8). As before, the major portion of the exports was to Ceylon, which took a largely increased quantity of coal; substantial and increased quantities of coal were also sent to the Straits Settlements, the Philippine Islands and Guam, whilst exports to the westerly markets of Aden, Egypt and the United Kingdom ceased. This small decrease in total exports reflects the difference between the loss of the westerly markets named, which were secured temporarily in 1926 on account of the coal strike in England, and the continued recovery of markets in the east. If we exclude these westerly markets from the comparison, then we find that exports to normal markets expanded from 216,088 tons in 1925 to 400,008 tons in 1926 and 573,771 tons in 1927.

TABLE 8.—*Exports of Indian Coal and Coke during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
To—						
Aden and Dependencies.	59,842	7,42,971	55,446	..	..	..
Ceylon . . .	242,685	33,19,680	247,738	340,546	44,73,416	333,837
Egypt . .	105,711	13,39,840	99,951	..	..	.
Philippine Islands and Guam.	12,968	1,34,447	10,033	56,052	4,85,349	36,220
Straits Settlements (including Labuan).	117,246	15,15,873	113,125	145,933	16,06,709	119,904
United Kingdom .	51,363	5,51,295	41,141	62	2,920	218
Other countries .	27,109	2,96,054	22,094	31,240	3,55,526	26,532
TOTAL .	616,424	78,99,610	589,528	573,833	69,23,920	516,711
Coke	1,139	33,636	2,510	2,334	52,193	3,895
Total of Coal and Coke .	617,563	*79,33,246*	*592,033*	576.167	*69,76,113*	*520,606*

These largely increased normal export figures are, however, still below those of some earlier years, (*e.g.*, 1,224,758 tons in

1920); but as they are mainly the result of the first two years' operations of the Indian Coal Grading Board established for the purpose of certifying the quality of coal exported from the port of Calcutta, they must be taken as a favourable augury for the future prospects of this scheme for the rehabilitation of Indian coal in foreign markets, especially as the expansion for 1927 is but very little lower than that for 1926. The following table shows the amounts of different grades of coal exported during 1926 and 1927 under this scheme, (including sea-borne coal for railways in Southern India, for which no Grade Shipment Certificates were issued by the Coal Grading Board), the difference between the total amounts so exported (2,224,173 tons in 1927) and the total exports of Indian coal to foreign ports given in Table 8 (573,833 tons in 1927) being the amount of coal exported to Indian ports.

TABLE 9.—*Exports of Coal under Grading Board Certificates during 1926 and 1927.*

—	1926.	1927.
	Tons.	Tons.
Selected Grade	943,821	1,733,880
Grade I	228,640	373,632
Grade II	28,135	22,068
Grade III	7,822	4,054
Mixed grades	82,522	80,935
Under reference	193,361	9,604
Sea-borne coal for railways in S. India for which grade shipment certificates were not issued.	354,630	..
Total	1,838,931	2,224,173

The imports at the same time, following the heavy drop recorded in the previous Review, rose from 193,908 tons to 243,603 tons, 7,311 tons of the latter consisting of coke (*see* Table 10). This increase is due to a rise in the imports from South Africa and the United Kingdom, partially set off by a fall in the imports from Portuguese East Africa. The total imports are now only about half those of the pre-war quinquennium,

and the table 10A comparing pre-war imports and exports with the 1927 figures shows that it is no longer possible to attribute depression in the Indian coal industry to the competitive effect of foreign imported coal. The surplus of exports over imports during 1926 and 1927 was in fact of the same order of magnitude as the surplus during the pre-war quinquennium.

TABLE 10.—*Imports of Coal and Coke during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4.)		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
From—						
Australia . .	13,323	3,79,656	28,333	11,017	2,94,405	21,971
Portuguese East Africa	46,044	9,58,465	71,527	29,314	6,74,391	50,328
Union of South Africa	84,956	18,03,105	134,560	132,357	28,88,518	215,561
United Kingdom .	21,374	5,74,089	42,842	50,209	13,67,207	102,030
Other countries .	9,087	1,72,360	12,863	13,395	2,99,360	22,340
TOTAL	174,784	38,87,675	290,125	236,292	55,23,881	412,230
Coke	19,124	6,13,015	45,747	7,311	2,90,262	21,661
Total of Coal and Coke.	193,903	*45,00,690*	*335,872*	243,603	*58,14,143*	*533,891*

TABLE 10A.—*Excess of Exports over Imports of Coal.*

Year.	Exports.	Imports.	Excess of exports over imports.
	Tons.	Tons.	Tons.
Average for 1909-1913	814,475	466,162	**348,313**
1926	617,563	193,908	**423,655**
1927	576,167	243,603	**332,564**

The average number of persons employed in the coalfields during the year showed an appreciable decrease in spite of the substantial increase in production. The average output per person employed, therefore, again showed an advance on the previous year, the figure of 110·5 tons for 1925 rising to 113·1 tons for 1926 and 122·3 tons in

1927; the figures for the last two years are higher than has previously been recorded, and indicate a higher average grade of efficiency in the mines at work than has hitherto been attained. This increased output per person employed is specially marked in Assam, Bengal, Bihar and Orissa, the Central Provinces and Hyderabad. There was, however, a small increase in the number of deaths by accident; these amounted to 196, which is, nevertheless, a considerable improvement on the annual average for the quinquennium 1919-23, which was 274; in addition, it relates to production 2⅓ million tons in excess of the average for 1919-23. The death-rate was 1·1 per thousand persons employed in 1927 against 0·99 for 1926; the average figure for the period 1919-23 was 1·36.

TABLE 11.—*Average number of persons employed daily in the Indian Coalfields during the years 1926 and 1927.*

—	Number of persons employed daily. 1926.	1927.	Output per person employed, in tons.	Number of deaths by accident.	Death-rate per 1,000 persons employed.
			Tons.		
Assam	4,523	4,034	80·2	11	2·7
Baluchistan	232	323	44·7	1	3·1
Bengal	43,498	44,274	125·5	36	0·8
Bihar and Orissa	112,945	109,196	133·0	122	1·1
Central India	2,497	3,259	66·8	2	0·6
Central Provinces	8,366	6,553	101·8	7	1·1
Hyderabad	12,134	11,464	61·7	13	1·1
Punjab	1,388	1,260	49·8	4	3·2
Rajputana	166	169	102·7	..	..
Total	**185,749**	**180,532**	..	*196*	..
Average	..	..	*122·3*	..	*1·1*

It is of interest to summarize the changes in the coal position during 1927 as revealed by the foregoing statistics. In spite of an increased output of over 1 million tons, or 5 per cent., during 1927, compared with the trivial increase of ½ per cent. during 1926, the fall in the average pit's mouth value of coal, as exemplified by the chief producing province, Bihar and Orissa, was less than in the preceding year, *viz.*, from Rs. 4-9-6 to Rs. 3-15-11 against the fall from Rs. 5-11-3 per ton in 1925 to Rs. 4-9-6 in 1926. This decrease in the rate of fall in price may be correlated with increased exports of Indian coal to eastern ports during 1927, with increased exports of coal under Grading Board certificates to foreign and Indian ports, and also with the fact that a much larger proportion of the coal exported under Grading Board certificates consisted of selected grade coal during 1927 than in 1926. Imports increased slightly, but to a smaller extent than the increase in exports to eastern ports; the excess of exports over imports was on a pre-war scale. The average output per person employed increased, and deaths by accident were below the average for the last quinquennial period. There was a reduction in stocks at the mines during the year, slightly greater than the excess of exports over imports. These factors, considered together, suggest that the Indian coal industry is now reaching a position of relative stability, that production has adjusted itself to demand, and that the point has been reached at which a further serious fall in prices is improbable. The data indicate that this position has been reached by an increasing proportional production from the seams of higher grade coal by the better organised companies.

Copper.

Work at the Mosaboni Mine of the Indian Copper Corporation, Ltd., in the Singhbhum district, was practically suspended during the year 1926, pending the raising of the capital required for the erection of the necessary concentrating, smelting, refinery and power plants. Early in 1927 the Anglo-Oriental and General Investment Trust, Ltd., London, assumed control, a sum of £350,000 was subscribed and the erection of the new plant commenced at once at the company's new site at Moubhandar, Ghatsila, together with an assisted siding from the Bengal-Nagpur Railway main line at Ghatsila, and an aerial ropeway from the mine.

The ore reserves (surface and underground) now amount to 624,539 short tons, with an average assay value of 3·88 per

cent. copper representing a copper content of 24,232 tons. The quantity of ore raised in 1927 was 5,000 tons valued at Rs. 2,00,000 (£14,925). This is in addition to 35,823 tons previously produced during development.

In addition there is now a regular production of copper matte at the Namtu smelting plant of the Burma Corporation, Ltd., assaying on the average about 41 per cent. of copper, 35 per cent. of lead and 70 ounces of silver to the ton. The production during 1926 was 11,441 tons valued at Rs. 44,78,064 (£334,184) and averaging 41·6 per cent. of copper and during 1927, 11,872 tons valued at Rs. 44,13,205 (£329,344) averaging 40·3 per cent. of copper. The matte is exported to Hamburg for further treatment.

A small output in 1926 of 4 tons of copper ore valued at Rs. 160 (£12) and in 1927 of 10 tons valued at Rs. 400 (£30) was reported from the Nellore district of Madras.

Diamonds.

The production of diamonds in Central India rose from 68·60 carats valued at Rs. 28,559 (£2,131) in 1926 to 112·74 carats valued at Rs. 44,943 (£3,354) in the year under review.

Gold.

In 1927 there was an arrest in the secular decline in the total Indian gold production. A small decrease of some 1,176 ounces from Mysore and the cessation of the abnormal production of gold in Singhbhum in 1927 was more than counterbalanced by an enhanced output from the new lease of the North Anantapur Gold Mines, Ltd., in the Anantapur district of Madras. Although this company ceased operation in July 1927, yet the net result was an increase of 114 ounces in the total gold output of India.

Of the five mines producing gold on the Kolar Gold Field the Champion Reef and the Ooregum mines attained vertical depths of 6,610·5′ and 6,483·5′ respectively below field datum at the close of the year 1927. There has been a slight drop in the estimated ore reserves mainly due to restricted development operations, but the deepest points so far reached indicate that further exploration will probably permit an increased estimate. Brick and concrete-lined shafts and winzes are coming more and more into prominence,

as they greatly facilitate the ventilation of the deeper levels. Rockbursts still continue to give trouble, and experiments are being made to minimise their effects by substituting a more rigid form of support instead of the usual timbering and waste rock filling of the excavations. Systematic building of granite packwalls in stopes in the Ooregum mine and filling the bottom of levels with mass concrete in the Champion Reef mine are being tried to prevent the sagging of the hanging wall, and it is hoped that the frequency of rockbursts will be reduced by this new method. The persistence of payable oreshoots in the deeper levels is a very encouraging feature of this year's development work.

Owing to the great depth of the mines and the high rock temperatures—117° F. in the bottom workings—the problem of ventilation has been an extremely difficult one. It has been solved to some extent by sinking deep vertical shafts and by an extensive use of large electrically driven fans to help the main air currents.

The total number of persons employed in the Kolar mines is 18,918.

TABLE 12.—*Quantity and value of Gold produced in India during the years 1926 and 1927.*

—	1926.			1927.			Labour.
	Quantity	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).		
	Ozs.	Rs.	£	Ozs.	Rs.	£	
***Bihar and Orissa*—**							
Singhbhum .	123·0	6,600	493	..	..	..	..
***Burma*—**							
Katha . .	24·2	1,491	111	11·5	778	58	8
Upper Chindwin.	122·4	11,127	830	48·2	4,169	311	115
Kashmir . .	46·7	1,995	149	48·0	2,048	153	128
***Madras*—**							
Anantapur .	(a) 930·0	53,219	3,972	(a) 2,395·0	1,37,320	10,248	411
Mysore . .	(a) 382,890·3	2,16,89,632	1,618,629	(a) 381,723·0	2,16,54,394	1,615,999	18,918
Punjab . .	8·8	444	33	42·5	1,645	123	60
United Provinces	4·1	275	21	4·3	275	21	16
Total .	**384,156·5**	***2,17,64,783***	***1,624,238***	**384,272·5**	***2,18,00,629***	***1,626,913***	**19,656**

(a) Fine gold.

Iron.

The production of iron-ore in India has been steadily on the increase; in 1927 there was an increase over the previous year of 11·3 per cent., amounting to 187,440 tons. The figures shown against the Mayurbhanj State in Table 13 represent the production by the Tata Iron and Steel Co., Ltd., whilst of that recorded against Singhbhum 507,580 tons were produced by the Tata Iron and Steel Co., Ltd., from their Noamundi mine, 302,258 tons by the Bengal Iron Co., Ltd., from their Pansira, Ajita and Maclellan mines, and 191,724 tons by the Indian Iron and Steel Co., Ltd., from their mines at Gua; the remaining 5,475 tons were produced by two other firms. The output of iron-ore in Burma is by the Burma Corporation, Limited, and is used as a flux in lead smelting.

TABLE 13.—*Quantity and value of Iron-ore produced in India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar and Orissa—						
Keonjhar	..	..	..	36,325	(a) 1,08,975	8,132
Mayurbhanj	1,041,929	31,25,787	233,267	692,137	20,76,411	154,956
Sambalpur	569	3,930	293	561	3,930	293
Singhbhum	552,079	12,84,922	95,890	1,007,037	25,34,346	189,130
Burma—						
Northern Shan States	(a) 48,089	1,92,356	14,355	61,062	(a) 2,44,248	18,228
Central India	230	1,406	105	230	1,410	105
Central Provinces	972	3,987	298	918	3,846	287
Mysore	(b) 15,427	73,278	5,468	48,465	1,28,695	9,604
Total	1,659,295	*46,85,666*	*349,676*	1,846,735	*51,01,861*	*380,735*

(a) Estimated.
(b) Excludes 1,909 tons of hæmatite quartzite.

The output of iron and steel by the Tata Iron and Steel Co., Ltd., at Jamshedpur works again showed an increase: the production of pig-iron rose from 609,429 tons in 1926 to 624,028 tons in 1927, and of steel (including steel rails) from 360,980

tons in 1926 to 414,738 tons in 1927; but the production of ferro-manganese fell from 10,503 tons in 1926 to 5,092 tons in 1927. The production of pig-iron by the Bengal Iron Co., Ltd., recovered from the low figures of 52,674 tons in 1925 and 20,050 tons in 1926 to 132,649 tons in 1927; their output of products made from this pig-iron increased, however, from 44,454 tons of sleepers and chairs and 26,364 tons of pipes and other castings in 1926 to 61,494 tons and 26,431 tons respectively in 1927. There was a large increase in the production of pig-iron by the Indian Iron and Steel Co., Ltd., from 253,431 tons in 1926 to 363,516 tons in 1927.

The Mysore Iron Works commenced producing pig-iron in 1923, when the quantity manufactured amounted to 9,732 tons; in the year under review the output of pig-iron amounted to 19,858 tons against 19,523 tons in 1926.

The number of indigenous furnaces that were at work in the Central Provinces during the year 1927 for the purpose of smelting iron-ore was 5 less than in the previous year; 95 furnaces were operating in the Bilaspur district, 48 in Raipur, 47 in Mandla, 11 in Drug, 3 in Saugor and 1 in Jubbulpore, making 206 in all.

There was a further increase in the production of pig-iron in India from 902,433 tons in 1926 to 1,140,051 tons, whilst the quantity exported rose from 309,505 tons in 1926-27 to 393,249 tons in 1927-28. Table 14 will show that Japan was the principal consumer of Indian pig-iron in 1927-28, nearly 69 per cent. of the total exports going to that country. There was a very slight rise in the export value, which was Rs. 45·1 (£3·37) per ton in 1926-27 and Rs. 45·4 (£3·39) in the following year.

The Steel Industry (Protection) Act, 1924—Act No. XIV of 1924—authorised, to companies employing Indians, bounties, which were granted upon rails and fishplates wholly manufactured in British India from material wholly or mainly produced from Indian iron-ore and complying with specifications approved by the Railway Board, and upon iron or steel railway wagons a substantial portion of the component parts of which had been manufactured in British India. This Act was repealed by the Act No. III of 1927 and consequently the payment of bounties ceased on the 31st March 1927, but the Industry is protected to a certain extent by varying tariffs on different classes of imported steel.

TABLE 14.—*Exports of Pig-iron from India during 1926-27 and 1927-28.*

—	1926-27.			1927-28.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
To—						
United Kingdom .	16,159	7,29,617	54,449	21,060	9,51,223	70,987
Germany . . .	2,868	1,29,086	9,633	12,227	5,50,157	41,057
Italy	858	38,607	288	2,958	1,33,931	9,995
China . . .	7,616	3,31,296	24,724	4,009	2,25,365	16,817
Japan . . .	234,529	1,05,71,787	788,939	270,956	1,23,54,921	922,009
United States of America	40,783	18,33,744	136,847	65,064	29,22,187	218 074
Other countries . .	6,742	3,29,146	27,156	16,975	7,37,350	55,026
Total .	309,555	*1,39,63,283*	*1,042,036*	393,249	*1,78,75,134*	*1,333,965*

Jadeite.

The fall in the output of jadeite, which commenced after the year 1922, has now ceased, and the output, which in 1926 amounted to only 1,203·9 cwts. valued at Rs. 2,34,456 (£17,497) increased in 1927 to 2,227 cwts. valued at Rs. 2,39,064 (£17,841). The output figures are liable to be incomplete, and a more correct idea of the extent of the Burmese jadeite industry is sometimes obtainable from the export figures. Exports by sea fell slightly from 2,139 cwts. valued at Rs. 4,70,225 (£35,091) in 1926-27 to 1,961 cwts valued at Rs. 3,02,440 (£22,570). The shipments were made entirely from Burma. These figures exclude exports by land across the frontier to foreign countries as the registration of the Land Frontier Trade of Burma has been discontinued. The average exports for the past 4 years have amounted to a little less than half the average figures for the previous three quinquennial periods (4,660 cwts. annually).

Lead.

Corresponding to an increase in the production of lead-ore at the Bawdwin mines of Burma, the total amount of metal extracted increased from 54,330 tons of lead including 1,057 tons of antimonial lead, valued at Rs. 2,25,94,634 (£1,686,167) in 1926, to 65,967 tons of lead including 503 tons of antimonial lead, valued at Rs. 2,20,27,742 (£1,643,861) in 1927. The quantity of silver extracted from Bawdwin ores also increased from 5,103,646 ozs. valued at Rs. 88,49,722 (£660,427) in 1926 to 6,004,437 ozs. valued at Rs. 94,67,196 (£706,507) in 1927. The value of both lead and silver fell respectively from Rs. 415·8 (£31·0) per ton and Rs. 1-11-9 (31·06*d.*) per oz. in 1926 to Rs. 333·9 (£24·9) per ton and Rs. 1-9-3 (28·24*d.*) per oz. in the year under review.

TABLE. 15.—*Production of Lead-ore, Lead and Silver during the years 1926 and 1927.*

—	1926.					1927.				
	Quantity.	Value. (£1=Rs. 13·4).				Quantity.	Value. (£1=Rs. 13·4).			
	Lead-ore.	Lead-ore and lead.		Silver.		Lead-ore.	Lead-ore and lead.		Silver	
	Tons.	Rs.	£	Rs.	£	Tons.	Rs.	£	Rs.	£
Burma—										
Northern Shan States	362,505	(a)2,25,94,634	1,686,167	(b)88,49,722	660,427	449,817	(c)2,20,27,742	1,643,861	94,67,196(d)	706,507
Southern Shan States	375	55,905	4,179	..	..	960	96.000	7,164	..	..
Yamethin . .	24	960	72	..	..	..	..	..	..	..
Rajputana—										
Jaipur State . .	6·6	1,170	87	..	..	..	..	..	..	..
Total . .	362,910·6	*2,26,52,759*	*1,690,505*	*88,49,722*	*660,427*	450,777	*2,21,23,742*	*1,651,025*	*94,67,196*	*706,507*

(a) Value of 53,273 tons of lead (Rs. 2,22,74,134) and 1,057 tons of antimonial lead (Rs. 3.20,500) extracted.
(b) Value of 5,103,646 oz. of silver extracted.
(c) Value of 65,464 tons of lead (Rs. 2,18,94,677) and 503 tons of antimonial lead (Rs. 1,33,065) extracted
(d) Value of 6,004,437 ozs of silver extracted.

Magnesite.

In 1926 the total Indian magnesite production was the highest yet recorded, namely, 30,461 tons valued at Rs. 3,54,355 (£26,444). In 1927 the production fell seriously to 19,638 tons valued at Rs. 2,29,338 (£17,115). The output for 1927 is, however, about the same as the average for the three years 1921 to 1923.

TABLE 16.—*Quantity and value of Magnesite produced in India during 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1=Rs. 13·4).		Quantity.	Value (£1=Rs. 13·4)	
	Tons.	Rs.	£	Tons.	Rs.	£
Madras—						
Salem	28,676	3,41,925	25,517	16,966	2,02,656	15,124
Mysore State	1,785	12,430	927	2,672	26,682	1,991
Total .	3 ,461	*3,54,355*	*26,444*	19,638	*2,29,338*	*17,115*

Manganese.

A rise in the output of manganese-ore in India has again to be recorded, the total for 1926, 1,014,928 tons, valued at £2,590,357 f. o. b. Indian ports, rising to 1,129,353 tons, valued at £2,844,237 f. o. b. Indian ports during the year under consideration. The figures for output in 1926 and 1927 are the highest yet recorded and exceed that for 1907, when 902,291 tons were raised. It will be noticed that concurrently with a rise in output there was, also, in contrast to the change recorded in the previous year, a rise in value, the total value for 1927 being £253,880 greater than that for 1926. In 1924 first-grade ore c. i. f. United Kingdom ports fetched an average price of 22·9*d.* per unit; in 1925 this price fell to 21·5*d.* and in 1926 to 18*d.* During 1927 the price fell from 19·9*d.* in January to 16·5*d.* in September and recovered to 17*d.* in December, the average for the year being again 18*d.* Consequently the increase in total value is proportionate to the increase in total quantity. A fall in price was anticipated in view of the agreement, two or three years ago, between an American group of financiers and the Soviet Government for the development on modern

lines of the manganese-ores of the Caucasus; the extent to which meanwhile such developments have actually taken place is not known, but from 1925 onwards there has been a large increase in the total output of Russia and Georgia, but only to figures that obtained before the war. Difficulties over the carrying out of the concession appear to have been frequent, and it is now reported that the group in question have decided to abandon the concession. There appears to be no reason for supposing that this will produce any serious effect upon the market for manganese-ore.

In addition to the four chief manganese-producing areas, India, Georgia (with Russia), Brazil and the Gold Coast, a further source at Postmasburg in the northern part of the Cape Province is promising; the grade is high and the deposits extensive, the only drawback being the presence of aluminous compounds.

The increase in the Indian output is shared by all provinces except the Central Provinces and by almost all districts, the only decreases being in Gangpur State in Bihar and Orissa and the Bhandara and Balaghat districts in the Central Provinces and the Bellary district in Madras. In the case of the output from Bihar and Orissa substantial increases occurred in Keonjhar and Singhbhum. In the Bombay Presidency the Panch Mahals showed a large increase to nearly 79,000 tons, the highest figure hitherto recorded. Chota Udaipur and Belgaum show small increases, whilst the initial production recorded from North Kanara in 1926 was doubled. After a break of several years Jhabua State in Central India had resumed production in 1924; it shows a third substantial increase amounting to 2,541 tons in the year under review. The most important Indian manganese area, namely, the Central Provinces, shows however, a decrease of some 17,500 tons in 1927 as contrasted with an increase of over 139,000 tons in 1926, the decreases in Balaghat and Bhandara being only partly balanced by the increase in the Nagpur district. In Madras the output of Sandur State increased by over 60,000 tons to 138,196 tons, the previous highest production being 97,091 tons in 1907. There is also a substantial increase in Vizagapatam and a small decrease in Bellary. Mysore shows a small total increase in output shared by the three producing districts.

The exports of manganese-ore, which fell in 1926 by 125,300 tons, increased in 1927 by 230,000 tons to 843,821 tons, as shown in Table 18. The highest export recorded was 862,777 tons in 1922. There is a steady consumption of manganese-ore at the works of the three prin-

cipal Indian iron and steel companies, not only for use in the steel furnaces of the Tata Iron and Steel Company, and the manufacture of ferro-manganese, but also for addition to the blast-furnace charge in the manufacture of pig-iron. The consumption of manganese-ore by the industry in 1927 was 39,065 tons, some 2,000 tons less than in the previous year.

TABLE 17.—*Quantity and value of Manganese-ore produced in India during 1926 and 1927.*

—	1926.		1927.	
	Quantity.	Value f.o.b. at Indian ports.	Quantity.	Value f.o.b. at Indian ports.
	Tons.	£	Tons.	£
Bihar and Orissa—				
Gangpur State	10,379	26,856	7,960	20,928
Keonjhar State	23,810	47,322	51,115	103,721
Singhbhum	2,473	6,399	9,970	26,213
Bombay—				
Chhota Udaipur	10,000	25,500	11,729	30,398
Belgaum	4,290	10,100	4,515	11,871
North Kanara	2,000	5,175	4,005	10,530
Panch Mahals	57,325	148,328	78,802	207,184
Central India—				
Jhabua State	7,969	16,901	10,510	22,728
Central Provinces—				
Balaghat	336,579	921,385	313,556	871,424
Bhandara	152,858	418,449	130,211	*361,878
Chhindwara	42,242	115,637	47,264	131,355
Jubbulpore	100	274	181	503
Nagpur	229,586	628,492	252,637	702,120
Madras—				
Bellary	8,853	14,054	6,004	9,782
Sandur State	77,327	122,757	138,196	225,144
Vizagapatam	21,698	37,339	31,992	56,386
Mysore State—				
Chitaldrug	1,599	2,645	4,021	6,819
Shimoga	23,032	38,099	23,658	40,120
Tumkur	2,808	4,645	3,027	5,133
Total	**1,014,928**	*2,590,357*	**1,129,353**	*2,844,237*

Table 19 shows the distribution of the manganese-ore exported from British Indian ports (excluding the Portuguese port of Mormugao) during 1926 and 1927, from which it will be seen that the amount absorbed by the United Kingdom in 1927 was nearly three times what it was in 1926, and that the United Kingdom has recovered her posi-

tion as the chief importer of Indian manganese-ore. The quantity exported to Belgium fell by 11,500 tons, but even so this country is not far behind Britain. France maintained her previous figure; small declines in the cases of Holland and Italy were amply balanced by a large increase on the part of the United States and smaller increases by Germany and Japan.

TABLE 18.—*Exports of Manganese-ore during 1926 and 1927 according to Ports of Shipment.*

Port.	1926.	1927.
	Tons.	Tons.
Bombay	222,371	249,360
Calcutta	291,745	418,173
Madras	9.800	13.910
Mormugao (Portguese India)* . .	89,620	162,378
Total .	**613,536**	**843,821**

* In addition 2,376 tons of manganese-ore produced in Portuguese India were exported.

TABLE 19.—*Exports of Manganese-ore from British Indian Ports during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
To—						
United Kingdom .	74,750	20,80,509	155,262	211,401	55,09,751	411,176
Germany . . .	6,346	1,48,800	11,104	12,805	2,99,967	22,386
Netherlands . .	14,800	4,25,125	31,726	12,500	3,52,000	26,269
Belgium . . .	185,974	51,25,666	382,512	174,485	50,33,543	375,637
France . . .	151,906	42,60,342	317,936	151,100	41,84,919	312,307
Italy	9,600	4,00,398	29,880	5,150	1,85,250	13,825
Japan . . .	8,290	2,31,854	17,303	15,502	3,44,481	25,708
United States of Amrica	67,250	20,15,500	150,411	97,500	27,22,502	203,171
Other countries . .	5,000	75,000	5,597	1,000	34,250	2,556
Total .	**523,916**	*1,47,63,194*	*1,101,731*	**681,443**	*1,86,66,663*	*1,393,035*

Mica.

There was a small increase in the declared production of mica from 41,924 cwts. valued at Rs. 22,19,367 (£165,624) in 1926 to 42,614 cwts. valued at Rs. 24,52,055 (£182,989) in 1927. As has been frequently pointed out, the output figures are incomplete, and a more accurate idea of the size of the industry is to be obtained from the export figures. It will be seen from table 21 that in both the years 1926 and 1927 the quantity exported was roughly double the reported production. The United States of America and the United Kingdom, which are the principal importers of Indian mica, absorbed 52 per cent. and 35 per cent. respectively of the total quantity exported during 1926 and 23·7 per cent. and 49·4 per cent. respectively during 1927. During this latter year Germany took 14·2 per cent. of the quantity exported. The average value of the mica exported fell slightly from Rs. 122 (£9·1) per cwt. in 1926 to Rs. 119·5 (£8·9) per cwt. in 1927.

The difference between exports and production is generally attributed to theft from the mines and early in 1928 a bill was introduced into the Legislative Council of Bihar and Orissa, the purpose of which was to attempt to reduce the losses on this account by licensing miners and dealers. The bill was, however, rejected.

TABLE 20.—*Quantity and value of Mica produced in India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4)	
	Cwts.	Rs.	£	Cwts.	Rs.	£
Bengal—						
Bankura	4	233	17	..	..	..
Bihar and Orissa—						
Gaya	1,782	1,21,855	9,094	1,513	1,08,926	8,129
Hazaribagh	26,789	13,46,376	100,476	29,419	16,07,216	119,942
Monghyr	748	39,808	2,971	615	28,063	2,094
Sambalpur	11	500	37	17	418	31
Gwalior	320	10,548	787	240	7,431	555
Madras—						
Nellore	11,271	5,98,532	44,667	9,265	5,93,874	44,281
Nilgiris	813	45,152	3,369	281	39,612	2,956
Rajputana—						
Ajmer-Merwara	538	46,863	3,497	971	49,752	3,713
J ipur	..	..	..	4	400	30
Shahpura	153	9,500	709	289	16,863	1,258
Total	41,924	*22,19,367*	*165,624*	42,614	*24,52,055*	*182,989*

TABLE 21.—*Quantity and value of Mica exported from India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
To—						
United Kingdom . .	31,618	44,13,886	329,394	38,298	43,00,239	320,913
Germany	4,984	3,97,105	29,635	11,014	8,69,478	64,887
France	1,340	2,69,630	20,122	3,876	3,71,246	27,705
United States of America .	47,038	51,94,255	387,631	18,410	30,73,548	229,369
Other countries . .	4,967	7,25,201	54,119	5,890	6,49,461	48,467
Total .	89,947	*1,10,00,077*	*820,901*	77,488	*92,63,972*	*691,341*

Monazite.

The monazite industry of Travancore, which was almost dead in the year 1925, when the reported production was 1 cwt. only, showed signs of revival in 1926, the output amounting to 64·2 tons valued at £947. This revival continued in 1927, when the output increased to 280 tons valued at £3,810. The decline of the industry is of course due to the supplanting of incandescent mantles for gas lighting by electricity. It is hoped that ilmenite collected with the monazite and hitherto regarded as a bye-product may be the means of reviving the whole industry. Titania forms a valuable white paint superior to white lead in being non-poisonous and in possessing twice the covering power.

Nickel.

As a bye-product in the smelting operations of the Burma Corporation, Limited, at Namtu, in the Northern Shan States, there is now a regular production of nickel speiss, which is exported to Hamburg for further treatment. Figures of production have not been received. The first sales, which occurred during 1927, were of 814 tons averaging 24 per cent. of nickel and valued at Rs. 1,34,978 (£10,073). Such speiss

contains, in addition, some 10 per cent. of copper and 30 ozs. of silver to the ton.

Petroleum.

The world's production of petroleum in 1926 amounted to a little over 151⅓ million tons, of which India contributed 0·79 per cent. In 1927 the world's production jumped to some 171 million gallons, of which the Indian proportion on a practically stationary production fell to 0·72 per cent. India is now eleventh on the list of petroleum producing countries, having been overtaken during 1927 by Columbia and Argentina. In the previous Review attention was drawn to the effect on prices of the greatly increased production of the United States and of the expansion in the output of light petroleum distillates obtained by cracking and from casing-head sources. In 1927 prices fell still lower in India at the same time as large supplies of kerosine from Georgia and Russia made their appearance on the Indian market.

As remarked before, petroleum statistics prove that it is becoming more and more difficult to maintain the output of India (including Burma) at the high levels it reached in 1919 and 1921, when peak productions of well over 305½ million gallons were reached. During the year under consideration, the total production amounted to a little over 281 million gallons against less than 280½ million gallons in 1926 and a little over 289½ million gallons in 1925. Although, therefore, this year there has not been an actual decrease, this can only be regarded as an arrest in the decline that has set in, and which, with possible interruptions, is likely to continue slowly and steadily during the present generation, unless a new field of importance is discovered. The changes of the latter recede year by year as exhaustive geological research continues to prove fruitless. A conservative policy rather than one of intensive development seems indicated, especially in view of the national importance of this mineral asset. In contrast with the almost stationary figure of output in 1926 and 1927, the value of the oil produced fell enormously from over 7 millions sterling in 1926 to less than 4½ millons sterling in 1927.

As before, the Yenangyaung field of Upper Burma shows a decided decrease in output. In 1924 it succeeded in showing an increase of nearly 6½ million gallons, but this temporary arrest in the decline was more than balanced by the drop in 1925 of over 21¼ million

gallons; in 1926 the drop amounted to 14½ million gallons; and in 1927 to 8⅛ million gallons. It is interesting to note that the production in Yenangyaung still includes oil derived from the old Burmese hand-dug wells.

It is now seldom that a new well strikes a yield of over 100 barrels per initial 24 hours. The utilization of the shallow oil-sands of this field, which were shut off during the competitive rush for the richer deep sands, continues; many remunerative wells are now being worked from two shallow zones, one at about 350 feet and the other at about 650 feet, and the production from shallow wells during 1927 amounted, in fact, to nearly 14 per cent. of the total production from the field. In spite of the fact that the fall in the yield of these wells is unexpectedly gradual, the effect in delaying the decline of the field may be looked upon as but temporary. The average daily yield of these shallow wells is about 2 barrels. The electrification of the field, which reached its limit of practicability in 1924, has added and is adding an appreciable contribution to the production figure, owing to the saving of a considerable quantity of crude oil formerly used as fuel beneath rig boilers.

Of the companies operating in this small field the Burmah Oil Company produce about four-fifths of the total output. Of undrilled portions of the Yenangyaung field the northern areas are showing more promise than the southern. There is now good reason to believe that as the depth increases, the crest of the anticline recedes more and more to the east; this means that the producing limits of oil pools will be found further and further eastwards as greater depths are attained. Deep test wells are being put down to prove this.

The place of Yenangyaung is being steadily taken by the Singu field, which will soon usurp the premier position so far held by the older field. Singu, the greater part of which is in the hands of the Burmah Oil Company, is used to make good the deficiencies of Yenangyaung, in order to maintain supplies to the refinery. In 1927 Singu produced nearly 3 million gallons more than it did in 1926, but this was not enough to counterbalance the decrease in the older field. Many wells are producing from the 3,000-foot sand and initial yields of 500 barrels and over are not uncommon. Progress in the electrification of the Singu field has been made by the completion of the transmission line from Yenangyaung.

Yenangyat field has now reduced itself to the status of the Upper Chindwin field and is out-classed by Minbu. Some deep tests are

now being sunk in this field in the hope of reviving production. A scheme by which the sandbank stretching southwards from the wells at Lanywa into the river Irrawaddy is to be protected by a revetted embankment is being carried out and has enabled a number of wells to be drilled by the Indo-Burma Petroleum Company on the sand-bank. Strictly speaking, the area belongs to the Singu dome area, but for convenience of administration it will be looked upon officially as part of the Yenangyat field.

Of the other Burma fields Thayetmyo shows a small recovery instead of a decline, as also does the Upper Chindwin. The increase in Upper Chindwin took place in spite of serious interference with operations due to phenomenal floods. The production from Minbu increased by 666,530 gallons, while the Arakan fields maintain their usual small output.

In Assam in the Surma valley the Bạdarpur field again showed a decrease in output by over 1 million gallons. This decrease is due to partial exhaustion of the proved sands and also to less drilling. There was a small initial production from Masimpur, also in the Surma valley. In Upper Assam, on the other hand, the Digboi field showed an increase in production, amounting to nearly 1¾ million gallons. Extensions to the refinery have been put in hand, and when these are complete, a large increase in output from this field may be anticipated. The results of the prospecting operations of the Assam Oil Company at Dhekiajuli, Dilli and Burragolai have been very disappointing, and although oil was obtained in the Burragolai well, the quantity was not sufficient to be of commercial value.

In the Punjab the production was more satisfactory than for some years, for the output from the Khaur field rose by nearly 4½ million gallons during 1927.

There was a marked rise in the imports of kerosene due to small increases in supplies from the United States, the Straits Settlements (including Labuan), and Borneo, reinforced by 12½ million gallons from Georgia and Russia, from which the imports in 1926 were *nil*.

The quantity of fuel oil imported into India during 1926 was, as Table 24 will show, nearly 6 million gallons more than that received during the previous year, the total imports reaching 100 million gallons. Over three-quarters of the supply was derived from Persia, and the greater part of the rest from Borneo.

The export of paraffin wax increased to the extent of some 7,000 tons during 1927 (*see* Table 25).

TABLE 22.—*Quantity and value of Petroleum produced in India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Gals.	Rs.	£	Gals.	Rs.	£
Assam—						
Badarpur . .	3,210,838	6,77,068	50,527	1,912,593	4,98,937	37,234
Digboi . . .	20,887,697	35,68,314	266,292	22,604,187	38,59,866	288,050
Masimpur . .	..	..	..	25,485	6,648	496
Burma—						
Akyab . .	6,331	2,191	164	5,627	1,948	145
Kyaukpyu . .	15,103	15,946	1,190	15,452	15,687	1,171
Minbu . .	4,583,420	10,15,297	75,769	5,199,950	11,10,406	82,866
Singu . . .	95,745,504	3,59,04,564	2,679,445	98,691,437	2,09,71,930	1,565,069
Thayetmyo . .	974,620	2,18,274	16,289	999,500	2,12,394	15,850
Upper Chindwin .	1,255,840	94,188	7,029	1,825,120	1,36,884	10,215
Yenangyat . .	1,778,041	3,39,865	25,363	1,844,946	3,84,359	28,685
Yenangyaung .	145,731,612	5,45,00,540	4,067,204	137,322,012	2,93,81,716	2,192,665
Punjab—						
Attock. . .	6,230,320	15,57,580	116,237	10,667,600	26,66,900	199,022
Total .	280,369,326	*9,78,93,827*	*7,305,509*	281,113,909	*5,92,47,675*	*4,421,468*

TABLE 23.—*Imports of Kerosene Oil into India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Gals.	Rs.	£	Gals.	Rs.	£
From—						
Borneo . .	6,291,079	36,66,389	273,611	7,734,388	40,11,512	299,367
Georgia . .	..	..	..	10,248,988	59,88,067	446,871
Russia . .	..	..	..	2,329,308	16,74,189	124,939
Straits Settlements (including Labuan).	3,726,437	22,27,811	166,254	5,294,469	23,05,617	172,061
Sumatra . .	915,971	6,37,814	47,598	13,000	13,338	995
United States of America.	58,325,929	3,93,34,516	2,935,412	60,250,875	4,04,81,594	3,021,015
Other countires .	51,820	46,401	3,463	2,287,599	9,79,932	73,129
Total .	69,311,236	*4,59,12,931*	*3,426,338*	88,158,627	*5,54,54,249*	*4,138,377*

TABLE 24.—*Imports of Fuel Oils into India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
From—	Gals.	Rs.	£	Gals.	Rs.	£
Persia . . .	69,344,118	1,40,50,401	1,048,537	77,872,989	1,58,09,773	1,179,834
Straits Settlements (including Labuan).	1,525,957	4,27,245	31,884	8,615,530	11,09,027	82,763
Borneo . .	23,597,902	61,30,911	457,531	16,316,240	45,71,036	341,107
Other countries .	125,001	23,095	1,724	2,480,777	6,85,744	51,175
Total .	94,592,978	*2,06,31,652*	*1,539,676*	100,285,536	*2,21,76,180*	*1,654,939*

TABLE 25.—*Exports of Paraffin Wax from India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
To—	Tons.	Rs.	£	Tons.	Rs.	£
United Kingdom .	16,147	76,40,615	570,195	14,398	67,48,807	503,642
Belgium . . .	4,810	21,88,550	163,325	5,783	26,76,485	199,738
Netherlands . .	2,645	11,92,418	88,986	3,537	16,11,254	120,243
China. . . .	2,942	15,89,289	118,604	2,897	13,91,856	103,870
Union of South Africa .	3,074	13,98,695	104,380	2,340	10,79,881	80,588
Portuguese East Africa	3,732	16,99,422	126,823	4,568	26,98,359	201,370
United States of America.	785	3,57,175	26,655	2,380	10,83,850	80,884
Australia . . .	1,127	5,13,476	38,319	867	3,94,628	29,450
New Zealand . .	241	1,09,655	8,183	464	2,11,574	15,789
Other countries . .	5,120	23,45,052	175,004	10,466	47,84,010	357,015
Total .	40,628	*1,90,34,347*	*1,420,474*	47,700	*2,26,80,704*	*1,692,589*

Ruby, Sapphire and Spinel.

A severe decline in the output from the Mogok ruby mines of Upper Burma in 1924, followed in 1925 by a marked drop in value,

bore witness to a serious decline in the industry. The Burma Ruby Mines, Limited, ultimately decided to go into liquidation and the mines were offered for sale in September, 1926. The skeleton organisation left in charge of the mines has, however, made good use of its opportunities, with the result that the value of the output in 1926 exceeded that of the previous year by over a *lakh* of rupees. This encouraging result was effected by rigorous economy and an extension of a system of co-operation with local miners, and was assisted by some good finds of sapphires in the Kyaungdwin mine (the only one still worked by European methods).

During 1927, however, production fell in value by over 1¾ lakhs of rupees, due mainly to a decrease in the value of the sapphires (and spinels) produced, there being a slight increase in the value of the rubies won.

There was a reported production in Kashmir of 1·6 cwts. in 1926 and 11 cwts. in 1927 of "corundum with sapphire patches". The value was not stated.

TABLE 26.—*Quantity and value of Ruby, Sapphire and Spinel produced in India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Carats.	Rs.	£	Carats.	Rs.	£
Burma	(a)	1,07,988 (Rubies).	8,059	(a)	1,18,000 (Rubies).	8,806
	(a)	3,41,750 (Sapphires).	25,504	(a)	1,61,500 (Sapphires).	12,052
	(a)	17,034 (Spinels).	1,271	(a)	334 (Spinels).	25
Total		*4,66,772*	*34,834*		*2,79,834*	*20,883*

(a) Quantity not reported.

Salt.

There was a small decrease in the total output of salt amounting to 26,804 tons, all provinces and states contributing to this decrease except Madras, which showed an increase of 61,255 tons, Gwalior with a small increase, and Kashmir with a stationary output of 1 ton!

TABLE 27.—*Quantity and value of Salt produced in India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Aden	194,524	9,35,531	69,815	181,757	8,74,489	65,260
Bombay and Sind . .	473,127	25,33,686	189,081	432,993	23,12,426	172,569
Burma	24,409	5,60,391	41,820	19,918	5,52,196	41,209
Gwalior (*a*) . . .	176	9,267	692	435	23,362	1,743
Kashmir	1	55	4	1	56	4
Madras	481,826	42,81,239	319,496	543,081	47,63,741	355,503
Northern India . .	464,686	28,93,350	215,922	433,765	28,53,885	212,977
Total .	1,638,749	*1,12,13,519*	*836,830*	1,611,945	*1,13,80,155*	*849,265*

(*a*) Figures relate to official years 1926-27 and 1927-28.

The total output of rock-salt increased by 24,077 tons.

TABLE 28.—*Quantity and value of Rock-salt produced in India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Salt Range . . .	122,895	6,26,760	46,778	145,750	8,45,720	63,113
Kohat	19,224	62,188	4,637	21,161	68,225	5,092
Mandi	4,552	1,02,549	7,653	3,837	92,112	6,874
Total .	146,671	*7,91,447*	*59,068*	170,748	*10,06,057*	*75,079*

There was a considerable increase, amounting to 121,898 tons, in the imports of salt, for which the United Kingdom, Spain, Egypt and Italian East Africa were chiefly responsible. The receipts from Germany also increased, while imports from Aden showed a small decrease.

TABLE 29.—*Imports of Salt into India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
From—						
United Kingdom .	52,741	11,76,368	87,789	83,523	27,56,487	205,708
Germany . . .	44,507	10,69,459	79,810	55,029	16,73,437	124,883
Spain . . .	51,655	9,97,043	74,406	89,328	25,63,902	191,336
Aden and Dependencies	187,420	36,29,761	270,878	182,696	54,40,838	406,033
Egypt . . .	122,232	24,90,858	185,885	148,873	42,43,591	316,686
Italian East Africa .	43,926	7,90,833	59,017	63,062	17,36,872	129,617
Other countries . .	13,317	2,83,448	21,153	15,185	4,38,786	32,745
Total .	515,798	*1,04,37,770*	*778,938*	637,696	*1,88,53,913*	*1,407,008*

Saltpetre.

Although statistics of production of saltpetre in India are no longer available, the export figures may be accepted as a fairly reliable index to the general state of the industry. Excepting a few hundreds of tons required for internal consumption as fertilizer, almost the whole of the output is exported to foreign countries. The quantity exported in 1927 amounted to 123,018 cwts. valued at Rs. 15,22,666 (£113,632) against 98,830 cwt. valued at Rs. 13,24,540 (£98,846) in 1926.

A certain amount of nitrate of potash is used for agricultural purposes on the tea gardens of India. During the War when it was impossible to obtain supplies of imported potash the amount of locally produced nitrate utilized in this way reached an appreciable figure. The practice continued and the quantities estimated to have been absorbed for fertilising purposes on tea gardens in 1923, 1924, 1925 and 1926 were 1,000, 1,100, 800 and 700 tons respectively. In 1927 this figure is estimated to have been 500 tons. The decrease during the last three years is due to the fact that it is found cheaper to employ a mixture of imported sulphate of ammonia and muriate of potash.[1]

[1] From information kindly supplied by Messrs. Shaw, Wallace and Co.

TABLE 30.—*Distribution of Saltpetre exported from India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
To—						
United Kingdom .	15,038	1,80,044	13,436	18,320	1,54,074	11,496
Ceylon . . .	61,930	7,16,452	53,467	86,410	9,42,667	70,348
Straits Settlements (including Labuan).	5,567	96,838	7,226	3,856	57,548	4,295
Hongkong . . .	11,281	2,39,440	17,869	2,050	92,300	6,888
Mauritius and Dependencies.	1,946	31,598	2,358	13,870	2,12,907	15,889
Other countries . .	3,068	60,173	4,490	3,512	63,170	4,714
Total .	98,880	*13,24,540*	*98,846*	128,018	*15,22,666*	*113,632*

Silver.

The production of silver from the Bawdwin mines of Upper Burma, increased from 5,103,646 ozs. valued at Rs. 88,49,722 (£660,427) in 1926 to 6,004,437 ozs. valued at Rs. 94,67,196 (£706,507) in 1927. The output of silver obtained as a bye-product from the Kolar gold mines of Mysore decreased to the extent of 2,163 ozs.

TABLE 31.—*Quantity and value of Silver produced in India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	oz.	Rs.	£	oz.	Rs.	£
Burma— Northern Shan States .	5,103,646	88,49,722	660,427	6,004,437	94,67,196	706,507
Madras— Anantapur .	59	94	7	149	125	9
Mysore Kolar . . .	22,383	35,222	2,629	20,220	31,220	2,330
Total .	5,126,088	*88,85,038*	*663,063*	6,024,806	*94,98,541*	*708,846*

Tin.

In contrast to the considerable increase recorded in the previous Review there was a small decrease in the production of tin-ore in Burma from 3,548 tons valued at Rs. 61,01,858 (£455,362) in 1926 to 3,495 tons valued at Rs. 66,17,773 (£493,864) in 1927. This decrease was due to decreases in the output of Tavoy and the Southern Shan States partly balanced by a further considerable increase in the output of Mergui. Dredging and hydraulicking for tin-ore are on the increase in both the Tavoy and Mergui districts and resultant increases in the output of both districts may be anticipated. The output of mixed cassiterite-wolfram concentrates from the Mawchi mines in the Southern Shan States was 1,466 tons. The composition of these concentrates is usually 43 per cent. wolfram to 57 per cent. cassiterite, so that for the purpose of this review 836 tons have been assumed to be cassiterite and the remainder wolfram. There is no recorded output of block tin.

Imports of unwrought tin increased from 51,103 cwts. valued at Rs. 94,72,957 (£706,937) in 1926 to 60,529 cwts. valued at Rs. 1,16,72,352 (£871,071) in 1927; 98 per cent. of these imports came from the Straits Settlements. Wrought tin to the extent of 441 cwts. valued at Rs. 57,759 (£4,310) was also imported into India during the year under review.

TABLE 32.—*Quantity and value of Tin-ore produced in India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Burma—						
Mergui . . .	703	12,86,522	96,009	1,163	26,04,760	194,385
Southern Shan States .	972	(*a*) 16,71,840	124,764	836	(*a*) 15,82,548	118,101
Tavoy . . .	1,861	31,22,496	233,022	1,489	24,15,465	180,259
Thaton . . .	12	21,000	1,567	7	15,000	1,119
Total .	**3,548**	*61,01,858*	*455,362*	**3,495**	*66,17,773*	*493,864*

(*a*) Estimated.

TABLE 33.—*Imports of unwrought Tin (blocks, ingots, bars and slabs) into India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Cwt.	Rs.	£	Cwt.	Rs.	£
From—						
United Kingdom .	1,480	2,79,824	20,882	871	1,79,418	13,389
Straits Settlements (including Labuan).	49,157	90,96,626	678,853	59,234	1,14,15,558	851,907
Other countries .	466	96,507	7,202	424	77,376	5,775
Total .	**51,103**	*91,72,957*	*706,937*	**60,529**	*1,16,72,352*	*871,071*

Tungsten.

During 1927 the output of wolfram decreased by some 324 tons to 1,160 tons, the decrease being shared by the three producing areas. Figures of export of wolfram from Burma are published annually, but from internal evidence it seems likely that they include the mixed tin-tungsten concentrates of the Southern Shan States; they are, therefore, not repeated here.

TABLE 34.—*Quantity and value of Tungsten-ore produced in India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Burma—						
Mergui . . .	9	5,618	419	8	4,070	304
Southern Shan States .	733	(*a*)3,58,999	26,791	630	(*a*) 3,09,330	23,084
Tavoy . .	742	4,06,347	30,325	522	2,56,603	19,149
Total .	**1,484**	*7,70,964*	*57,535*	**1,160**	*5,70,003*	*42,537*

(*a*) Estimated.

Zinc.

The production of zinc concentrates by the Burma Corporation, Ltd., in the Northern Shan States amounted to 58,286 tons valued at Rs. 73,19,468 (£546,229) in 1927 against 48,834 tons valued at Rs. 63,24,491 (£471,977) in 1926. The exports during the year under review amounted to 67,135 tons valued at Rs. 70,06,018 (£522,737) against 43,056 tons valued at Rs. 43,03,775 (£321,177) in the preceding year.

III.—MINERALS OF GROUP II.

Alum. The output, during the year under review, of alum in the Mianwali district, Punjab, amounted to 1,419 cwts. valued at Rs. 23,160 (£1,728) against 2,647 cwts. valued at Rs. 50,400 (£3,761) in 1926.

Amber. The production of amber in the Myitkyina district, Burma, rose from 39·5 cwts. valued at Rs. 21,420 (£1,599) in 1926 to 70·6 cwts. valued at Rs. 27,180 (£2,028) in 1927.

Apatite. There was a further decrease in the production of apatite in the Singhbhum district, Bihar and Orissa, which amounted to 603 tons valued at Rs. 10,045 (£750) against 718 tons valued at Rs. 10,770 (£804) in 1926.

Asbestos. Of the total production of 67·7 tons of asbestos, valued at Rs. 13,554 (£1,011), 40 tons were produced in the Seraikela State of Bihar and Orissa, 22 tons in the Cuddapah district, Madras, and 5·7 tons in Ajmer-Merwara, Rajputana.

Barytes. The output of barytes fell from 2,311 tons valued at Rs. 9,244 (£690) in 1926 to 1,719 tons valued at Rs. 9,890 (£738) in 1927. Of this 851 tons were produced from the Kurnool district of Madras and 868 tons from the Alwar State of Rajputana.

Bauxite. There was again a small decrease in the total production of bauxite, which fell from 4,956 tons valued at Rs. 36,768 (£2,744) in 1926 to 4,310 tons valued at Rs. 28,240 (£2,107) in 1927. Of this 3,345 tons were produced in the Kaira district of Bombay and 965 tons in Jubbulpore district of the Central Provinces.

Beryl. No output of beryl was reported during the year under review.

Bismuth. During 1927, 48 lbs. of native bismuth valued at Rs. 128 (£10) were produced in the Tavoy district. The only previous recorded production of this metal was of 0·71 cwt. valued at Rs. 240 (£17) from the same district in 1924.

Borax. Borax is produced from the Puga valley in the Ladakh tahsil of Kashmir State. The production in 1927 was 3·6 cwts. valued at Rs. 20 (£1·5).

Building materials and road-metal.

The total estimated value of building materials and road-metal produced in the year under consideration was Rs. 1,22,50,103 (£914,187). Certain returns supplied in cubic feet have been converted into tons on the basis of certain assumed relations between volume and weight. The total production of 3,249,378 tons of limestone and *kankar* includes the production of 59,679 tons of dolomite produced in the Gangpur State, Bihar and Orissa, mainly for use as flux in the iron and steel industry. This decreased production of dolomite in Gangpur compared with 1926 (135,424 tons) is due to the progressive replacement by limestone as a flux in the iron and steel industry.

TABLE 35.—*Production of Building Materials and*

—	Granite and Gneiss.		Laterite.		Lime.		Limestone and Kankar.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	Rs.	Tons.	Rs.	Tons	Rs.	Tons.	Rs.
Assam . . .	4,616	17,240	17,478	29,985	..	..	69,476	1,13,629
Baluchistan . .	..	..	..	..	..	..	2	180
Bengal . .	134,125	1,65,153	..	..	..	..	..	..
Bihar and Orissa .	356,361	4,18,447	1,835	603	..	..	(a) 1,026,663	21,13,764
Bombay . . .	..	..	1,400	3,300	..	..	..	..
Burma . .	622,756	12,29,978	262,035	4,01,633	..	..	324,042	5,75,852
Central India . .	..	..	..	..	17,457	2,00,305	128,577	96,024
Central Provinces .	..	..	..	..	..	..	474,348	6,97,150
Gwalior . . .	..	..	..	..	..	..	..	..
Kashmir . . .	..	..	..	..	132	4,450	..	..
Madras . . .	16,055	8,981	94,386	82,684	..	..	13,518	13,668
Mysore . . .	..	..	720	9,000	2,047	35,186	3,399	6,170
N.-W. F. Province .	..	..	..	..	..	..	2,073	1,959
Punjab . . .	..	..	..	..	..	..	454,669	5,95,016
Rajputana . .	..	..	..	..	..	..	(b) 192,807	2,45,985
United Provinces .	..	..	..	..	..	..	(c) 559,804	7,24,685
Total .	1,133,913	*18,39,799*	377,854	*5,27,205*	19,636	*2,39,941*	3,249,378	*51,84,082*

(a) Includes 59,679 tons of dolomite.
(b) Includes 80 tons of dolomite.
(c) Include 542,128 tons of kankar used for metalling roads.

Road-metal in India during 1927.

Marble.		Sandstone.		Slate.		Trap.		Miscellaneous.		Total value (£1 = Rs. 13·4).	
Quantity.	Value.	Quantity.	Value.	Quantity.	Value	Quantity	Value.	Quantity.	Value.		
Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Rs.	£
..	..	..	..	..	..	..	..	46,084	2,25,542	3,86,396	28,836
..	..	..	..	..	..	..	..	..	..	180	13
..	..	..	..	..	..	..	..	..	..	1,65,153	12,325
..	..	18,583	20,752	1,929	36,466	3,822	5,028	312,503	3,45,558	29,40,618	219,449
..	..	6,500	11,000	..	..	26,959	1,61,274	1,086,058	7,59,947	9,35,521	69,815
..	..	110,817	1,45,807	..	..	..	..	574,546	6,11,657	29,64,927	221,263
..	..	3,714	30,200	..	..	..	..	..	..	3,26,529	24,368
..	..	538	732	..	..	..	..	49,730	41,156	7,39,038	55,152
..	..	13,824	43,870	..	..	..	..	..	..	43,870	3,274
..	..	..	..	93	340	..	..	18,054	22,030	26,820	2,002
..	..	..	..	..	..	..	..	140,067	1,38,896	2,44,229	18,226
..	..	..	..	16	1,400	..	..	11,845	45,645	97,401	7,269
..	..	..	..	..	..	..	..	..	..	1,959	146
..	..	..	..	5,005	1,23,827	..	..	68,932	73,228	7,92,071	59,110
5,635	1,35,264	168,269	5,20,896	230	950	..	..	38,160	50,176	9,53,271	71,139
..	..	28,803	28,654	568	7,485	..	..	463,391	8,71,296	16,32,120	121,800
5,635	*1,35,264*	*351,048*	*8,01,911*	*7,841*	*1,70,468*	*30,781*	*1,66,302*	*2,809,879*	*31,85,131*	*1,22,50,103*	*914,187*

Clays. There was a decrease in the recorded production of clay, which fell from 192,838 tons valued at Rs. 4,39,620 (£32,807) in 1926 to 129,177 tons valued at Rs. 2,65,572 (£19,819) in 1927.

TABLE 36.—*Production of Clays in India during 1927.*

—	1927.		
	Quantity.	Value (£1=Rs. 13·4).	
	Tons.	Rs.	£
Bengal	23,866	43,049	3,213
Bihar and Orissa	15,372	1,18,194	8,820
Burma	23,379	36,301	2,709
Central India	489	3,175	237
Central Provinces	52,446	31,775	2,371
Delhi	4,300	4,767	356
Gwalior	600	4,124	308
Kashmir	919	1,000	75
Madras	1,094	434	32
Mysore	6,003	21,168	1,580
Rajputana	709	1,585	118
Total	129,177	*2,65,572*	*19,819*

Copperas. The production of sulphate of iron in Ladakh, Kashmir State, fell from 14·6 cwts. valued at Rs. 27 (£2) in 1926 to 8 cwts. valued at Rs. 15 (£1) in 1927.

Corundum. The total production of corundum amounted to 65 tons valued at Rs. 8,023 (£598). Of this 13 tons were produced from the Bhandara district in the Central Provinces and 52 tons from the Salem district in Madras (See also under "Ruby, Sapphire & Spinel").

Fuller's Earth.

The reported production of fuller's earth fell from 3,456 tons in 1926 to 2,718 tons in 1927. Mysore is chiefly responsible for the decreased figure, but its returns are not always trustworthy owing to the illiteracy of the workers. Bikanir showed a considerable increase and Jodhpur a small decrease.

TABLE 37.—*Production of Fuller's Earth in India during the years 1926 and 1927.*

——	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4.)		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Central Provinces—						
Jubbulpore . .	..	..	..	35	173	13
Mysore . . .	1,479	3,759	281	214	539	40
Rajputana—						
Bikanir . .	918	5,511	411	1,469	9,335	696
Jaisalmer . . .	21	326	24	23	345	26
Jodhpur . . .	1,038	14,005	1,045	977	12,222	912
Total .	**3,456**	*23,601*	*1,761*	**2,718**	*22,614*	*1,687*

Gypsum.

There was a slight increase in the output of gypsum from 34,473 tons valued at Rs. 79,447 (£5,929) in 1926 to 38,105 tons valued at Rs. 89,809 (£6,702) in 1927. The effect of gypsum in small quantities upon crops—a common application is 2 maunds to the acre—is said to be remarkable, and its usefulness to the monsoon crops of South Bihar has been experimentally demonstrated.[1] The Department of Agriculture, Bihar and Orissa, is importing annually for this purpose gypsum from Jamsar in Bikanir. This experimental work may, therefore, ultimately result in a demand from agricultural districts for gypsum.

[1] D. Clouston. Review of Agricultural Operations in India, 1924-25, p. 52.

TABLE 38.—*Production of Gypsum in India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Kashmir . . .	121	677	51	..	..	.
Punjab—						
Jhelum . . .	1,337	3,008	225	4,112	7,065	527
Rajputana—						
Bikanir . . .	24,892	55,937	4,174	23,837	54,991	4,104
Jaisalmer . . .	123	825	61	156	1,003	75
Jodhpur . . .	8,000	19,000	1,418	10,000	26,750	1,996
Total .	34,473	*79,447*	*5,929*	38,105	*89,809*	*6,702*

Ilmenite. There was a very large increase in the production of ilmenite in the Travancore State, which amounted to 17,809 tons valued at £33,443 in 1927 against 4,236·3 tons valued at £7,587 in 1926. This mineral is collected with the monazite sands and, up to a few years ago, was looked upon as a bye-product of the monazite industry. The increasing demand for the titania in the ilmenite is causing a resuscitation of the monazite industry, which had been adversely affected by the increased use of electricity for lighting purposes. (See p. 231).

Ochre. There was a large increase in the production of ochre, which amounted to 3,472 tons valued at Rs. 27,477 (£2,051) against 1,872 tons valued at Rs. 30,177 (£2,252) in 1926. This increase is chiefly due to an output of 704 tons from the Jubbulpore district, Central Provinces, and of 697 tons from the Banda district, United Provinces, from both of which there was no production in the previous year.

TABLE 39.—*Production of Ochre in India during the years 1926 and 1927.*

	1926.			1927.		
	Quantity.	Value (£1=Rs. 13·4).		Quantity.	Value (£1=Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar and Orissa . .	79	11,060	824	..	..	..
Central India . .	(*a*) 806	(*a*) 6,301	471	760	2,822	211
Central Provinces . .	75	1,500	112	1,026	9,533	711
Gwalior . . .	323	6,937	518	316	4,162	311
Madras	275	3,750	280	350	4,750	354
Rajputana . . .	314	629	47	323	721	54
United Provinces . .	..	..	..	697	5,489	410
Total .	1,872	*30,177*	*2,252*	3,472	*27,477*	*2,051*

(*a*) Revised.

Refractory Materials.

Besides the production of 65 tons of corundum (see p. 248) there was an output entirely from Singhbhum of 425 tons of quartzite valued at Rs. 2,125 (£159) and of 4,425 tons of kyanite valued at Rs. 25,009 (£1,866), of which 3,665 tons were produced from the Lapso Hill mines in Kharsawan State. The total production of quartzite and kyanite amounted to 4,850 tons valued at Rs. 27,134 (£2,025) against 1,976 tons in 1926 valued at Rs. 21,755 (£1,624).

Serpentine.

No production of serpentine in the Skardu tahsil, Kashmir State, was recorded during the year.

Soda.

The production of soda in the Ladakh tahsil, Kashmir, fell from 20 tons valued at Rs. 733 (£55) in 1926 to 11 tons valued at Rs. 400 (£30) in 1927. Salt, consisting for the greater part of sodium carbonate, sodium bicarbonate and sodium chloride, is obtained by evaporation from the waters of the Lonar lake in the Buldana district of the Central Provinces. It is known under the general name of *trona* or *urao*, for which there is no suitable equivalent in English. The total amount of *trona* extracted in 1926 was 100 tons, the value of which was estimated at Rs. 3,000 (£224), but in 1927 there was no production, as the company working the concession has gone into liquidation. There was also a production of 1·8 tons of crude soda (*rasi*) valued at Rs. 49 (£3) in Datia State, Central India.

Steatite. During 1927 there was a great fall in the total Indian output of steatite due mainly to large decreases in the reported production of Singhbhum in Bihar and Orissa and Jaipur State in Rajputana.

TABLE 40.—*Production of Steatite in India during the years 1926 and 1927.*

—	1926.			1927.		
	Quantity.	Value (£1 = Rs. 13·4).		Quantity.	Value (£1 = Rs. 13·4).	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar and Orissa—						
Mayurbhanj . .	65·0	6,900	515	67·0	6,300	470
Seraikela . . .	11·0	600	45	19·4	1,060	79
Santhal Parganas .	..	..	..	110·0	1,654	123
Singhbhum . .	2,648·0	29,712	2,220	271·0	16,830	1,257
Burma—						
Pakokku Hill Tracts.	17·0	5,808	433	..	..	..
Central India—						
Bijawar . . .	208·0	1,972	147	202·0	1,920	143
Central Provinces—						
Bhandara . . .	..	..	..	250·0	10,000	746
Jubbulpore . .	800·0	16,439	1,227	870·0	10,960	818
Madras—						
Kurnool . . .	3·0	210	16	..	..	..
Nellore . . .	65·0	2,411	180	87·0	3,917	292
Salem . . .	480·0	12,549	936	795·0	19,438	1,451
Mysore	80·5	243	18	68·0	204	15
Rajputana—						
Jaipur . . .	5,074·0	64,200	4,791	2,206·0	30,000	2,239
United Provinces—						
Hamirpur . . .	78·0	8,686	648	8·0	760	57
Jhansi . . .	54·0	500	37	100·0	1,680	126
Total .	**9,678·5**	*1,50,260*	*11,213*	**5,058·4**	*1,04,732*	*7,816*

Zircon. Concurrently with large increases in the output of monazite (page 231) and ilmenite (page 250) in Travancore State in 1927, there was a large increase in the production of zircon in the same State, from 532 tons valued at £2,987 in 1926 to 1,465 tons valued at £8,129 in 1927.

IV.—MINERAL CONCESSIONS GRANTED.

TABLE 41.—*Statement of Mineral Concessions granted during the year 1927.*

AJMER-MERWARA.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Ajmer .	(1) Mr. E. P. Thomas, Mining Engineer.	Mica . . .	P. L. (renewal).	8·2	12th May 1927.	1 year.
Do. .	(2) Messrs. Abdul Gani & Co., Nasirabad.	Do. . .	P. L. .	0·3	24th June 1927.	Do.
Do. .	(3) Messrs. Radha Kishen Kanahayalal, Nasirabad.	Do. . . .	P. L. .	1·8	2nd July 1927.	Do.
Do. .	(4) Md. Sarfraz Ali, Ajmer.	Do. . . .	P. L. (renewal).	2·0	5th August 1927.	Do.
Do. .	(5) Mr. Dhirajlal Purushatam, Nasirabad.	Do. . . .	P. L. (renewal).	1 3	8th August 1927.	Do.
Do. .	(6) Do. .	Do. . . .	P. L. (renewal).	1·5	Do. .	Do.
Do. .	(7) Mr. L. Chhaganlal, Nasirabad.	Do. . . .	P. L. .	2·1	24th August 1927.	Do.
Do. .	(8) Mr. Nasarwanji D. Contractor, Kaisarganj.	Mica and beryl	P. L. .	1·8	3rd September 1927.	Do.
Do. .	(9) Messrs. Abdul Ghani & Co., Nasirabad.	Mica . . .	P. L. .	2·2	12th September 1927.	Do.
Do. .	(10) Messrs. Radha Kishen Kanahayalal & Co., Nasirabad.	Do. . . .	P. L. .	1·0	20th September 1927.	Do.
Do. .	(11) Mr. L. Chhaganlal, Nasirabad.	Do. . . .	P. L. (renewal).	17·2	23rd September 1927.	Do.
Do. .	(12) Mr. L. Prem Sukh Rathi, Nasirabad.	Do. . . .	P. L. .	1·9	26th September 1927.	Do.
Do. .	(13) Mr. Dhirajlal Purushatam, Nasirabad.	Do. . . .	P. L. (renewal).	3·1	30th September 1927.	Do.
Do. .	(14) Do. . .	Do. . . .	P. L. .	0·4	29th September 1927.	Do.
Do. .	(15) Do. . .	Do. . . .	P. L. .	2·4	11th October 1927.	Do.
Do. .	(16) Mr. J. K. Soneji & Co., Ajmer.	Do. . . .	M. L. .	Kalera Bogla Estate.	3rd February 1927.	7 years.
Do. .	(17) Mr. L. Chhaganlal Sau, Nasirabad.	Do. . . .	M. L. .	Para Estate .	27th August 1927.	3 years.
Beawar .	(18) The Rajputana Mineral Co., Ltd., Ajmer.	Graphite . .	P. L. (renewal).	7·3	24th August 1927.	1 year.
Do. .	(19) Do. . .	Mica . . .	P. L. (renewal).	0·4	Do. .	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

AJMER-MERWARA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Beawar .	(20) The Rajputana Mineral Co., Ltd., Ajmer.	Mica	P. L. (renewal).	7·0	24th August 1927.	1 year.
Do. .	(21) Do. . .	Do. . . .	P. L. (renewal).	7·0	Do. .	Do.
Do. .	(22) Mr. L. Chhaganlal Sau.	Do. . . .	P. L. .	3·5	Do. .	Do.
Do. .	(23) Mr. L. Prem Sukh Rathi, Nasirabad.	Do. . . .	P. L. .	2·2	19th September 1927.	Do.

ASSAM.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Cachar .	(24) Messrs. The Burma Oil Co., Ltd.	Mineral oil .	P. L. .	4,947·2	26th September 1926.	2 years.
Do. .	(25) Do. . .	Do. . .	P. L. .	1,088·0	3rd December 1926.	Do.
Khasi and Jaintia Hills.	(26) Messrs. D. D. Mukherjee and G. O. Mans.	Corundum and Sillimanite.	M. L. .	1,920·0	1st April 1927	30 years.
Lakhimpur	(27) Messrs. The Assam Oil Company, Ltd.	Mineral oil .	P. L. . (renewal).	5,120·0	30th March 1927.	1 year.
Do. .	(28) Do. . .	Do. . .	P. L. (renewal).	4,480·0	7th April 1927.	Do.
Do. .	(29) Do. . .	Do. . .	P. L. (renewal).	4,160·0	20th April 1927.	Do.
Do. .	(30) Do. . .	Do. . .	P. L. (renewal).	3,968·0	12th May 1927.	Do.
Do. .	(31) Do. . .	Do. . .	P. L. (renewal).	853·0	23rd April 1927.	Do.
Nowgong .	(32) Messrs. The Whitehall Petroleum Corporation, Ltd.	Crude petroleum and its associated Hydrocarbon.	P. L. (renewal).	1,920·0	20th March 1927.	Do.
Do. .	(33) Do. . .	Do. . .	P. L. (renewal).	1,344·0	Do. .	Do.
Do. .	(34) Do. . .	Do. .	P. L. (renewal).	1,344·0	9th April 1927.	Do.
Sadiya Frontier Tract.	(35) Messrs. The Assam Oil Co., Ltd.	Mineral oil .	P. L. .	2,240·0	19th December 1927.	Do.
Sibsagar .	(36) Do. . .	Oil and coal .	P. L. (renewal).	1,440·0	5th June 1927.	Do.
Do. .	(37) Messrs. The Burma Oil Company, Ltd.	Do. . .	P. L. (renewal).	6,400·0	9th June 1927.	Do.
Do. .	(38) Do. . .	Oil and its associated Hydrocarbon.	P. L. (renewal).	3,488·0	26th April 1927.	2 years.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BALUCHISTAN.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kalat .	(39) Messrs. The Burma Oil Co., Ltd.	Mineral oil . .	P. L. (renewal).	3,200	1st September 1927.	1 year.
Quetta-Pishin.	(40) Mian Mohamed Ismail of Quetta.	Coal and coal dust	M. L. .	80	10th November 1927.	30 years.
Sibi . .	(41) Messrs. The Burma Oil Co., Ltd.	Mineral oil . .	E. L .	261,120	21st October 1927.	1 year.
Zhob . .	(42) The Baluchistan Chrome Co., Ltd., Hindubagh.	Chrome . .	M. L. .	10	10th October 1927.	30 years.
Do. .	(43) Do. . .	Do. . .	M. L. .	10	Do. .	Do.
Do. .	(44) Do. . .	Do. . .	M. L. .	10	Do. .	Do.
Do. .	(45) Do. . .	Do. . .	M. L. .	10	Do. .	Do.
Do. .	(46) Do. . .	Do. . .	M. L. .	10 .	Do. .	Do.

BENGAL.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chittagong Hill Tracts.	(47) Messrs. The Burma Oil Co., Ltd.	Mineral oil . .	P. L. (renewal).	4,313·6	15th March 1927.	1 year.

BIHAR AND ORISSA.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Santal Parganas.	(48) Babu Binode Behari De.	Coal	M. L. .	1·90	1st April 1927	2 years.
Do. .	(49) Bansiram Marwari.	Do.	M. L. .	8·00	Do. .	Do.
Do. .	(50) Do. . .	Do.	M. L. .	5·00	Do. .	Do
Do. .	(51) Bhudhar Chandra De.	Do.	M. L. .	5·00	Do. .	Do
Do. .	(52) Ramrekh Das Marwari.	Do.	M. L. .	2·16	Do. .	Do
Do. .	(53) Bansiram Marwari.	Do.	M. L. .	1·90	Do. .	Do.
Do. .	(54) Do. . .	Do.	M. L. .	5·00	Do. .	Do
Do. .	(55) Gangaram Marwari.	Do.	M. L. .	1·82	Do. .	Do.
Do. .	(56) Bansiram Marwari.	Do.	M. L. .	0·33	Do. .	Do.
Do. .	(57) Do. . .	Do.	M. L. .	5·04	Do. .	Do.
Do. .	(58) Bhudhar Chandra De.	Do.	M. L. .	3·94	Do. .	Do
Do. .	(59) Do. . .	Do.	M. L. .	1·00	Do. .	Do

P. L.—*Prospecting License.* M. L.—*Mining Lease.*
E. L.—Exploring License.

BIHAR AND ORISSA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Santal Parganas	(60) Binode Behari De.	Coal . . .	M. L. .	2·15	1st April 1927	2 years.
Singhbhum	(61) Satya Charan Mukherji.	Chromite . .	M. L. .	296·00	26th June 1927.	20 years.
Do. .	(62) Messrs. Visanji Umarsee & Co.	Iron ore and Manganese.	P. L. .	134·70	1st March 1927.	1 year.
Do. .	(63) Dwarkadas Agarwalla.	Manganese . .	P. L. .	848·00	6th May 1927.	Do.
Do. .	(64) Do. . .	Do. . .	P. L. .	380·65	21st May 1927.	Do.
Do. .	(65) Arjun Ladha .	Do. . .	M. L. .	133·24	18th July 1927.	10 years.
Do. .	(66) Messrs. Lalji Jhina & Sons.	Iron ore . .	M. L. .	88·20	30th August 1927.	Do.
Do. .	(67) Hira Lall Sarda .	Manganese and iron ore.	P. L. .	1,612·80	20th December 1927.	1 year.
Do. .	(68) Do. . .	Do. . .	P. L. .	117·56	13th December 1927.	Do.

BOMBAY.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Belgaum .	(69) Messrs. Dalchand Bahadur Sing.	Bauxite . .	P. L. . (renewal).	1,625	14th July 1926.	3 years.
Do. .	(70) Mr. A. N. Peston Jamas.	Do. . .	P. L. . (renewal).	1,073	24th March 1926.	1 year.
Kanara .	(71) Bapursaheb Narayan Tilve.	Manganese . .	M. L. .	10·3	27th September 1927.	25 years.
Do. .	(72) Mr. T. B. Kantheria.	Do. . .	M. L. .	264	6th May 1927.	10 years.
Do. .	(73) Mr. K. Ramchandra.	Do. . .	M L. .	1,584	Do. .	Do.
Do. .	(74) Mr. E. H. Rushton.	Do. . .	P. L. .	584	19th August 1927.	1 year.
Do. .	(75) The Kanara Mining Syndicate.	Do. . .	P. L. .	594	1st November 1927.	Do.
Do. .	(76) Do. . .	Do. . .	P. L. .	1,212	Do. .	Do.

BURMA.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Akyab .	(77) Messrs. The Burma Oil Co., Ltd.	Natural petroleum (including natural gas)	P. L. .	9,408	9th May 1927.	2 years.
Do. .	(78) Messrs. The Indo-Burma Petroleum Co., Ltd. .	Do. . .	P. L. .	1,177·6	22nd April 1926.	Do.

P. L.—*Prospecting License.* M. L.—*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Akyab .	(79) Messrs. The Burma Oil Co., Ltd.	Natural petroleum (including natural gas.)	P. L. .	633·6	19th July 1927.	2 years.
Do. .	(80) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. .	5,440	15th December 1926.	Do.
Do. .	(81) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. .	4,051·2	19th October 1927.	Do.
Do. .	(82) Mg. Sein Ban .	Do. . .	P. L. .	15·6	23rd November 1927.	Do.
Do. .	(83) Messrs. The Indo-Burma Petroleum Co., Ld.	Do. . .	P. L. (renewal).	4,800	19th January 1927.	1 year.
Do. .	(84) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. (renewal).	1,280	2nd November 1927.	Do.
Amherst .	(85) Mr. A. C. Martin	All minerals except natural petroleum.	P. L. .	1,280	10th January 1927.	Do.
Do. .	(86) Messrs. Talaing Tin Ltd.	Do. . .	P. L. .	1,280	6th January 1927.	Do.
Do. .	(87) Mr. L. G. Cotte .	Do. . .	P. L. .	960	9th May 1927.	Do.
Do. .	(88) Saw Eu Hoke .	Do. . .	P. L. .	1,920	3rd May 1927.	Do.
Do. .	(89) Mr. A. C. Jeewa	Do. . .	P. L. .	1,280	23rd June 1927.	Do.
Do. .	(90) Mr. D. A. David	Do. . .	P. L. .	1,280	29th September 1927.	Do.
Do. .	(91) Messrs. Ahmed Moosa Motiwala & Sons.	Do. . .	P. L. .	1,120	23rd December 1927.	Do.
Do. .	(92) Messrs. Hosain Hamadanee and another.	Tin ore . .	M. L. .	1,008	16th March 1927.	10 years.
Do. .	(93) Messrs. Balthazar & Sons	Oil shale . .	P. L. (renewal).	5,760	26th February 1927.	* 31st March 1927.
Do. .	(94) Dr. M. Shawloo .	Do. . .	P. L. (renewal).	7,040	1st February 1927.	* 30th April 1927.
Do. .	(95) Saw Lein Lee .	Antimony . .	P. L. (renewal).	1,600	1st April 1927	* 30th June 1927.
Do. .	(96) Do. .	Do. . .	P. L. (renewal).	1,235·2	Do.	Do.
Do. .	(97) Messrs. Balthazar & Sons.	Oil shale . .	P. L. (renewal).	5,760	Do.	1 year.
Do. .	(98) Mr. A. C. Martin	All minerals except oil.	P. L. (renewal).	1,280	21st July 1927.	Do.
Do. .	(99) Mr. D. A. David	Do. . .	P. L. (renewal).	1,280	30th July 1927.	Do

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

* The period of the licenses has been extended to enable the licensees to apply for mining leases.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Amherst	(100) Mr. A. C. Martin	All minerals except oil.	P. L. (renewal).	640	18th October 1927.	Up to 31st March 1928.
Do.	(101) Dr. K. S. Kanga	Do.	P. L. (renewal).	550·4	6th December 1927.	1 year.
Lower Chindwin.	(102) Messrs. The Indo-Burma Petroleum Co., Ltd.	Natural petroleum (including natural gas).	P. L.	1,600	22nd September 1926.	2 years.
Do.	(103) Do.	Do.	P. L.	5,798·4	24th September 1923.	1 year.
Do.	(104) Messrs. The Burma Oil Co., Ltd.	Do.	P. L.	320	5th August 1927.	2 years.
Do.	(105) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do.	P. L.	825·6	30th July 1927.	Do.
Do.	(106) Do.	Do.	P. L. (renewal).	5,760	5th July 1927.	1 year.
Do.	(107) Messrs. The Burma Oil Co., Ltd.	Do.	P. L. (renewal).	2,560	13th November 1926.	Do.
Do.	(108) Do.	Do.	P. L. (renewal).	640	24th January 1927.	Do.
Do.	(109) Lawrence Dawson.	Do.	P. L. (renewal).	1,196·8	5th February 1927.	Do.
Do.	(110) Messrs. The Indo-Burma Petroleum Co., Ld.	Do.	P. L. (renewal).	5,760	5th July 1927.	Do.
Do.	(111) Do.	Do.	P. L. (renewal).	5,798·4	24th September 1927.	Do.
Magwe	(112) Messrs. The Burma Oil Co., Ltd.	Do.	P. L.	320	8th December 1927.	2 years.
Do.	(113) Messrs. The Hessford Development Syndicate.	Do.	P. L. (renewal).	640 640	26th November 1926. 12th June 1927.	Do.
Do.	(114) Mr. Abdul Rahaman.	Do.	P. L. (renewal).	1,280	27th July 1927.	1 year.
Do.	(115) Messrs. The British Burma Petroleum Co., Ltd.	Do.	P. L. (renewal).	70·4	26th August 1927.	Do.
Do.	(116) U. Thu Daw	Do.	P. L. (renewal).	2,560	15th October 1927.	Do.
Mergui	(117) Chan Khain Lock.	All minerals except mineral oil.	P. L.	704	13th May 1927.	Do.
Do.	(118) Joo Seng	Tin and allied minerals except mineral oil.	P. L.	486·4	22nd August 1927.	Do.
Do.	(119) Ma Tin	Do.	P. L.	716·8	15th March 1927.	Do.
Do.	(120) Messrs. Beadon and Doupe.	Do.	P. L.	576	25th April 1927.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

¹ Extended till the application for the mining lease over the two areas is disposed of.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(121) Mr. J. W. Newbery.	Tin . . .	P. L. .	1,203·2	31st March 1927.	1 year.
Do. .	(122) Mr. Rowland Ady.	All minerals except mineral oil.	P. L. .	3,225·6	23rd March 1927.	Do.
Do. .	(123) U. Shawe Yun .	Tin and allied minerals except mineral oil.	P. L. .	276	4th March 1927.	Do.
Do. .	(124) Mr. A. Herbert Noyes.	Tin and other allied metals except mineral oil.	P. L. .	83·[illegible]	21st May 1927.	Do.
Do. .	(125) Messrs. Austral Malay Tin Ltd.	Tin . . .	P. L. .	2,803·2	2nd March 1927.	Do.
Do. .	(126) Mr. R. A. Park	Do. . .	P. L. .	8[illegible]·6	16th Novem- 1927.	Do.
Do. .	(127) Mr. L. R. Beale	Tin and allied minerals except mineral oil.	P. L. .	704	4th May 1927.	Do.
Do. .	(128) Ah Khoon .	All minerals except oil.	P. L. .	64	25th March 1927.	Do.
Do. .	(129) Mr. A. E. Ahmed	Tin ore and other allied metals except mineral oil.	P. L. .	486·4	22nd February 1927.	Do.
Do. .	(130) Mr. J. I. Milne	Tin . . .	P. L. .	19·2	31st January 1927.	Do.
Do. .	(131) Do. .	Do. . .	P. L. .	64	Do. .	Do.
Do. .	(132) Mr. G. H. Hand	Do. . .	P. L. .	1,043·2	1st March 1927	Do.
Do. .	(133) Mr. W. R. Coleridge Beadon.	Tin and allied minerals except mineral oil.	P. L. .	377·6	29th June 1927.	Do.
Do. .	(134) Do. .	Do. . .	P. L. .	96	Do. .	Do.
Do .	(135) Dr. John Morrow Campbell.	Tin ore and gold	P. L. .	51,200	10th January 1927.	Do.
Do. .	(136) Mr. M. A. Noordin.	Tin and allied minerals except mineral oil.	P. L. .	883·2	22nd August 1927.	Do.
Do. .	(137) Mr. M. A. Musaji	All minerals except oil.	P. L. .	313·6	1st February 1927.	Do.
Do. .	(138) Mr. G. H. Hand	Tin . . .	P. L. .	44·8	1st March 1927.	Do.
Do. .	(139) Mr. Gul Mohamed.	Tin and allied minerals except mineral oil.	P. L. .	576	28th March 1927.	Do.
Do. .	(140) Mr. J. M. Forster	Do. .	P. L. .	640	22nd March 1927.	Do.
Do. .	(141) Do. . .	Do. .	P. L. .	640	Do. .	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
ergui .	(142) Mr. J. M. Forster.	Tin and allied minerals except minerol oil.	P. L. .	640	22nd March 1927.	1 year.
Do. .	(143) Do. . .	Do. .	P. L. .	640	Do. .	Do.
Do. .	(144) Lim Oo Gaing .	Tin and allied metals except oil.	P. L. .	204·8	3rd January 1927.	Do.
Do. .	(145) Messrs. Beadon and Doupe.	Do. .	P. L. .	403·2	3rd March 1927.	Do.
Do. .	(146) Mr. J. I. Milne .	Do. .	P. L. .	179·2	1st February 1927.	Do.
Do. .	(147) Mr. S. O. Holmes	Do. .	P. L. .	985·6	2nd June 1927.	Do.
Do. .	(148) Messrs. The Burma Finance and Mining Co., Ltd.	All minerals except oil.	P. L. .	652·8	28th June 1927.	Do.
Do. .	(149) Do. . .	Do. .	P. L. .	736	Do. .	Do.
Do. .	(150) Mr. E. B. Milne .	Do. .	P. L. .	716·8	4th June 1927.	Do.
Do. .	(151) Mr. L. R. Beale .	Tin and allied minerals.	P. L. .	883·2	4th May 1927	Do.
Do. .	(152) Dr. John Morrow Campbell.	All minerals except natural petroleum.	P. L. .	1,760	31st March 1927.	Do.
Do. .	(153) Do. .	Do.	P. L. .	2,560	31st March 1927.	Do.
Do. .	(154) Mg. E. Gyi .	Tin and allied minerals except mineral oil.	P. L. .	275·2	23rd March 1927.	Do.
Do. .	(155) Joo Seng . .	Tin and other minerals except oil.	P. L. .	1,049·6	30th November 1927.	Do.
Do. .	(156) Mr. A. H. Noyes	Tin ore and other allied metals except mineral oil.	P. L. .	153·6	21st May 1927.	Do.
Do. .	(157) Kwe Ya . .	Tin and allied minerals except mineral oil.	P. L. .	236·8	16th July 1927.	Do.
Do. .	(158) Mr. G. W. Bowden.	Do. .	P. L. .	544	22nd August 1927.	Do.
Do. .	(159) Tan Po Chit .	All minerals except mineral oil.	P. L. .	371·2	4th April 1927.	Do.
Do. .	(160) Leong Foke Hye	Tin and allied minerals except oil.	P. L. .	460·8	27th August 1927.	Do.
Do. .	(161) Do. .	Tin and allied minerals.	P. L. .	556·8	3rd May 1927	Do.
Do. .	(162) Messrs. Hand and Newbery.	Tin and allied minerals except mineral oil.	P. L. .	115·2	2nd June 1927.	Do.
Do. .	(163) En Gwan Kyin .	Tin	P. L. .	812·8	22nd June 1927.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(164) Maung Po .	Tin and allied minerals except mineral oil.	P. L. .	332·8	21st July 1927.	1 year.
Do. .	(165) Mr. A. H. Yunose	All minerals except oil.	P. L. .	576	7th June 1927	Do.
Do. .	(166) Messrs. Mayan Chaung Alluvials, Ltd.	Tin and allied minerals.	P. L. .	1,395·2	20th July 1927.	Do.
Do. .	(167) Mr. A. H. Noyes	Tin ore and other allied metals.	P. L. .	204·8	21st May 1927.	Do.
Do. .	(168) Tan Eik Kun .	Tin and allied minerals except mineral oil.	P. L. .	524·8	5th May 1927	Do.
Do. .	(169) Do. . .	Do. .	P. L. .	518·4	5th April 1927.	Do.
Do. .	(170) Do. . .	Do. .	P. L. .	601·6	Do. .	Do.
Do. .	(171) Mohamed Ismail	Do. .	P. L. .	857·6	7th October 1927.	Do.
Do. .	(172) Maung Kyin Bu	Do. .	P. L. .	51·2	10th June 1927.	Do.
Do. .	(173) Do. . .	Do. .	P. L. .	217·6	22nd September 1927.	Do.
Do. .	(174) Messrs. Mergui Tin Dredging Co., Ltd.	Tin ore and minerals other than mineral oil.	P. L. .	281·6	22nd August 1927.	Do.
Do. .	(175) Mr. M. A. Musaji	Tin and allied minerals except mineral oil.	P. L. .	281·6	20th July 1927.	Do.
Do. .	(176) Lee Quee Chee .	Tin . . .	P. L. .	627·2	22nd August 1927.	Do
Do. .	(177) Do. . .	Do. . . .	P. L. .	627·2	30th July 1927.	Do.
Do. .	(178) Do. . .	Do. . . .	P. L. .	627·2	Do. .	Do.
Do. .	(179) Messrs. Mayanchaung Alluvials, Ltd.	Tin and allied minerals except mineral oil.	P. L. .	2,329·6	16th August 1927.	Do.
Do. .	(180) Tan Eik Kun .	Tin and allied minerals except mineral oil.	P. L. .	160	5th May 1927	Do
Do. .	(181) Mr. M. A. Noordin.	Do. .	P. L. .	499·2	22nd August 1927.	Do.
Do. .	(182) Mr. H. G. Hand.	Tin and allied minerals.	P. L. .	780·8	8th October 1927.	Do.
Do. .	(183) Messrs. Mayanchaung Alluvials, Ltd.	Tin and allied minerals except mineral oil.	P. L. .	1,792	19th September 1927.	Do.
Do. .	(184) Mr. A. H. Noyes	Do. .	P. L. .	166·4	16th July 1927.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(185) Maung E. Gyi .	Tin and allied minerals except mineral oil	P. L. .	460·8	23rd September 1927.	1 year.
Do. .	(186) Mr. E. B. Milne .	All minerals except mineral oil.	P. L. .	441·6	31st August 1927.	Do.
Do. .	(187) Mr. A Herbert Noyes.	Tin ore and other allied metals except mineral oil.	P. L. .	217·6	9th September 1927.	Do.
Do. .	(188) Mr. J. W. Newbery.	Tin and allied minerals except mineral oil.	P. L. .	102·4	8th June 1927	Do.
Do. .	(189) Eng Tain Leong.	Tin . . .	P. L.	640	30th July 1927.	Do.
Do. .	(190) Leong Ah Foo .	Tin and allied minerals except mineral oil.	P. L. .	172·8	8th December 1927.	Do.
Do. .	(191) Leong Foke Hye	Do. . .	P. L. .	486·4	8th October 1927.	Do.
Do. .	(192) Yeo Sain Guan .	Do. . .	P. L. .	1984	5th September 1927.	Do.
Do. .	(193) Mr. Kapursingh	Tin . . .	P. L. .	844·8	23rd December 1927.	Do.
Do. .	(194) Mr. G. H. Hand.	Tin . . .	P. L. .	627·2	31st December 1927.	Do.
Do. .	(195) Yeo Sain Guan .	Tin and allied minerals except mineral oil.	P. L. .	800·0	5th September 1927.	Do.
Do. .	(196) Ah Shee . .	Tin ore . .	P. L. .	326·4	23rd December 1927.	Do.
Do. .	(197) Joo Seng . .	Do. . .	M. L. .	908·8	1st December 1927.	30 years.
Do. .	(198) Maung Po Thaik	Do. . .	M. L .	1,580·8	16th June 1927.	Do.
Do. .	(199) In Sit Yan .	All minerals except natural petroleum and natural gas.	M. L. .	1,075·2	16th September 1927.	Do.
Do. .	(200) Tan Po Chit and Tan Sine Shin.	Tin . . .	M. L. .	582·4	1st December 1926.	Do.
Do. .	(201) Maung San Dun	Do. . .	M. L. .	128	3rd August 1926.	Do.
Do. .	(202) Messrs. The Tavoy Tin Dredging Corporation, Ltd.	All minerals except natural petroleum.	P. L. .	1,011·2	9th January 1927.	1 year.
Do. .	(203) Do. . .	Do. . .	P. L. .	723·2	8th October 1927.	Do.
Do. .	(204) Do. . .	Do. . .	P. L. .	1,260·8	9th December 1927.	Do.
Do. .	(205) Do. . .	Do. . .	P. L. .	2,214·4	8th December 1927.	Do.

P.L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(206) Messrs. Tavoy Prospectors, Ltd.	All minerals except natural petroleum.	P. L. .	3,033·6	23rd November 1927.	1 year.
Do. .	(207) Mr. J. I. Milne .	Tin ore . .	P. L. .	556·8	10th December 1927.	Do.
Do. .	(208) Tan Boon Hein	Tin and allied minerals except natural petroleum.	P. L. .	454·4	1st December 1927.	Do.
Do. .	(209) Leong Ah Foo .	Do. . .	P. L. .	460·8	9th December 1927.	Do.
Do. .	(210) Dr. Henry E. Wells.	Tin and all minerals except coal and mineral oil.	P. L. (renewal).	371·2	3rd February 1927.	Do.
Do. .	(211) Do. . .	All minerals except coal and mineral oil.	P. L. (renewal).	320	12th April 1927.	Do.
Do. .	(212) Ma Kyin Mya and Ma Lin.	Tin . . .	P. L. (renewal).	428·8	4th May 1927	Do.
Do. .	(213) En Guan Kyin .	Do. . . .	P. L. (renewal).	1,580·8	Do. .	Do.
Do. .	(214) Maung E. Gyi .	Tin and allied minerals except mineral oil.	P. L. (renewal).	256	14th June 1927.	Do.
Do. .	(215) Messrs. Mayan-chaun Alluvials, Ltd.	Tin . . .	P. L. (renewal).	960	24th June 1927.	Do.
Do. .	(216) Mr. G. H. Hand.	Do. . . .	P. L. (renewal).	806·4	Do. .	Do.
Do. .	(217) Joo Seng . .	Tin and allied minerals except mineral oil.	P. L. (renewal).	473·6	9th August 1927.	Do.
Do. .	(218) Do. . .	All minerals except mineral oil.	P. L. (renewal).	985·6	1st August 1927.	Do.
Do. .	(219) Mr. F. L. Watts.	Tin and allied minerals except mineral oil.	P. L. (renewal).	1,196·8	9th August 1927.	Do.
Do. .	(220) Do. . .	Do. . .	P. L. (renewal).	256	Do. .	Do.
Do. .	(221) Mr. Gul Mohamed.	Tin and allied minerals except mineral oil.	P. L. (renewal).	576	31st July 1927.	Do.
Do. .	(222) Mr. M. A. Noordin.	Do. . .	P. L. (renewal).	256	Do. .	Do.
Do. .	(223) Mr. A. Aziz Yunose.	Do. . .	P. L. (renewal).	537·6	9th August 1927.	Do.
Do. .	(224) Leong Foke Hye	Do. . .	P. L. (renewal).	1,292·8	23rd August 1927.	Do.
Do. .	(225) Tan E. Kyin .	Do. . .	P. L. (renewal).	121·6	27th August 1927.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(226) Mr. G. H. Hand.	Tin . . .	P. L. (renewal).	2,912	4th September 1927.	1 year.
Do. .	(227) Ah Shee . .	Tin and allied minerals except oil.	P. L. (renewal).	249·6	30th October 1927.	Do.
Do. .	(228) Mr. E. Maxwell Lefroy.	Do. . .	P. L. (renewal).	684·8	Do. .	Do.
Do. .	(229) Mr. E. B. Milne .	All minerals except mineral oil.	P. L. (renewal).	1,254·4	1st December 1927.	Do.
Meiktila .	(230) Mr. S. L. B. Aldworth.	All minerals and coal.	P. L. .	345·6	21st September 1927.	Do.
Minbu .	(231) Messrs. The Burma Oil Co., Ltd.	Natural petroleum (including natural gas).	M. L. .	640	1st December 1927.	30 years.
Do. .	(232) Mr. L. Dhana Singh.	Natural petroleum.	P. L. (renewal).	320	10th March 1927.	1 year.
Do. .	(233) Do. . .	Do. . .	P. L. (renewal).	588·8	30th April 1927.	Do.
Myingyan .	(234) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. .	2,809·6	22nd December 1926.	2 years.
Northern Shan States.	(235) Sawbwa of Momeik.	All minerals and precious stones.	P. L. .	268·8	15th July 1927.	1 year.
Do. .	(236) Messrs. The Burma Corporation, Ltd.	Iron ore . .	M. L. .	172·8	1st May 1927	30 years.
Do. .	(237) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. (renewal).	192	2nd July 1927	1 year.
Do. .	(238) Do. . .	Do. . .	P. L. (renewal).	121·6	Do. .	Do.
Pakakku .	(239) Ma Bi Bi . .	Natural petroleum	P. L. .	640	22nd November 1926.	Do.
Do. .	(240) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. .	160	22nd March 1927.	2 years.
Do. .	(241) Do. . .	Do. . .	P. L. .	800	7th November 1926.	Do.
Do. .	(242) Mg. Myo Nyun, Agent of U. Thu Daw.	Do. . .	P. L. .	640	30th November 1927.	Do.
Do. .	(243) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. (renewal).	2,400	12th February 1927.	1 year.
Shwebo .	(244) Do. .	Do. .	P. L. (renewal).	5,113·6	12th March 1927.	Do.
Do. .	(245) Do. . .	Do. . .	P. L. (renewal).	5,440	14th August 1927.	Do.
Southern Shan States.	(246) Sawbwa of Lawksawk.	All minerals except oil.	P. L. .	12,000	1st November 1927.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Southern Shan State.	(247) Mr. Colin Campbell.	All minerals except oil.	P. L. .	640	15th July 1927.	1 year.
Do. .	(248) Mawchi Mines .	Do. . .	P. L. .	512	18th August 1927.	Do.
Do. .	(249) Messrs. The Kalaw Mining Syndicate.	Do. . .	P. L. . (renewal).	76·8	24th January 1926.	Do.
Do. .	(250) Do. . .	Do. . .	P. L. . (renewal).	4,320	27th July 1926.	Do.
Do. .	(251) Messrs. Steel Bros. & Co., Ltd.	Do. . .	P. L. . (renewal).	198·8	28th November 1926.	Do.
Do. .	(252) Mr. Colin Campbell.	Do. . .	P. L. . (renewal).	480	19th November 1926.	Do.
Do. .	(253) Do. . .	Do. .	P. L. . (renewal).	480	18th December 1926.	Do.
Do. .	(254) Do. . .	Do. . .	P. L. . (renewal).	480	1st November 1926.	Do.
Do. .	(255) Do. . .	Do. . .	P. L. . (renewal).	2,240	25th November 1926.	Do.
Do. .	(256) Tan Po Yin .	Do. . .	P. L. . (renewal).	358·4	9th December ber 1926.	Do.
Do. .	(257) Messrs. The Coalfields of Burma, Ltd.	Coal . .	P. L. . (renewal).	160	9th May 1926	2 years.
Do. .	(258) Messrs. The Shan States Silver, Lead Co., Ltd.	All minerals except oil.	P. L. . (renewal).	1,120	22nd December 1926.	1 year.
Do. .	(259) Messrs. Steel Bros. & Co.	Do. . .	P. L. . (renewal).	1,600	22nd February 1927.	2 years.
Do. .	(260) Daw Tui & Sons	Do. . .	P. L. . (renewal).	640	31st December 1926.	1 year.
Do. .	(261) Tan Po Yin .	Do. . .	P. L. . (renewal).	640	4th May 1927	Do.
Do. .	(262) Messrs. Kalaw Mining Syndicate.	Do. . .	P. L. . (renewal).	76·8	24th April 1927.	Do.
Tavoy .	(263) Messrs. The Burma Finance and Mining Co., Ltd.	Tin and wolfram	M. L. .	192	15th February 1927.	30 years.
Do. .	(264) Messrs. The Tavoy Tin Dredging Corporation, Ltd.	Do. . .	M. L. .	179·2	1st April 1927	Do.
Do. .	(265) Mr. H. Kelly .	Do. . .	M. L. .	889·6	16th June 1927.	Do.
Do. .	(266) Mr. W. C. Toms	Tin, Wolfram and allied minerals.	M. L. .	96	16th September 1927.	10 years.
Do. .	(267) Quah Cheng Gwan.	Do. . .	M. L. .	582·4	1st December 1926.	30 years.
Do. .	(268) U. Maung Maung.	Tin and wolfram	M. L. .	422·4	1st May 1927	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy .	(269) Mr. A. S. Mahomed.	Tin and Wolfram.	P. L. .	326·4	10th January 1927.	1 year.
Do. .	(270) Messrs. The Tavoy Prospectors, Ltd.	Do. . .	P. L. .	2,758·4	13th September 1927.	Do.
Do. .	(271) Mr. R. C. N. Twite.	Do. . .	P. L. .	435·2	27th January 1927.	Do.
Do. .	(272) Mr. A. W. Ross.	Do. . .	P. L. .	780·8	3rd February 1927.	Do.
Do. .	(273) Messrs. The Burma Finance and Mining Co.	Do. . .	P. L. .	64	31st January 1927.	Do.
Do. .	(274) Mrs. S. Wellington.	Do. . .	P. L. .	640	4th January 1927.	Do.
Do. .	(275) Mr. J. W. Newbery.	Do. . .	P. L. .	160	30th May 1927.	Do.
Do. .	(276) Mr. J. J. A. Page	Do. . .	P. L. .	70·4	10th March 1927.	Do.
Do. .	(277) Mr. J. W. Newbery.	Do. . .	P. L. .	230·4	30th May 1927.	Do.
Do. .	(278) Quah Hun Chaung.	Do. . .	P. L. .	275·2	3rd February 1927.	Do.
Do. .	(279) Messrs. The Tavoy Tin Dredging Corporation, Ltd.	Do. . .	P. L. .	1,036·8	7th May 1927	Do.
Do. .	(280) Do. . .	Do. . .	P. L. .	960	Do. .	Do.
Do. .	(281) U. Maung Muang.	Do. . .	P. L. .	960	4th July 1927	Do.
Do. .	(282) Mrs. S. Wellington.	Do. . .	P. L. .	288	21st June 1927.	Do.
Do. .	(283) Messrs. The Tavoy Tin Dredging Corporation, Ltd.	Do. . .	P. L. .	2,598·4	..	Do.
Do. .	(284) Mr. R. C. N. Twite.	Do. . .	P. L. .	38·4	10th March 1927.	Do.
Do. .	(285) Mr. A. W. Ross	Do. . .	P. L. .	128	16th April 1927.	Do.
Do. .	(286) Quah Cheng Guan.	Do. . .	P. L. .	640	6th May 1927	Do.
Do. .	(287) Maung Po Swe .	Do. . .	P. L. .	326·4	4th May 1927	Do.
Do. .	(288) Messrs. The Tavoy Rubber Co., Ltd.	Do. . .	P. L. .	32	6th July 1927	Do.
Do. .	(289) Mr. A. W. Ross.	Do. . .	P. L. .	108·8	26th May 1927.	Do.
Do. .	(290) Mrs. S. Wellington.	Do. . .	P. L. .	640	18th August 1927.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(291) Messrs. The Tavoy Tin Dredging Corporation, Ltd	Tin and wolfram .	P. L. .	1,715·2	18th September 1927.	1 year.
Do. .	(292) Messrs. The Burma Finance and Mining Co., Ltd.	Do. .	P. L. .	339·2	27th July 1927.	Do.
Do. .	(293) Mr. H. Kelly .	Do. .	P. L. .	428·8	30th May 1927.	Do.
Do. .	(294) Mr. R. C. N. Twite.	Do. .	P. L. .	1,996·8	1st November 1927.	Do.
Do. .	(295) Chan Kee .	Do. .	P. L. .	755·2	15th August 1927.	Do.
Do. .	(296) Messrs. The Tavoy Prospectors, Ltd.	Do. .	P. L. .	2,259·2	13th August 1927.	Do.
Do. .	(297) Mr. W. C. Toms	Do. .	P. L. .	512	22nd August 1927.	Do.
Do. .	(298) Mr. M. A. Musaji	Do. .	P. L. .	326·4	2nd December 1927.	Do.
Do. .	(299) Khoo Sein Shan	Do. .	P. L. .	640	3rd November 1927.	Do.
Do. .	(300) Messrs. The Tavoy Tin Dredging Corporation, Ltd.	Do. .	P. L. .	1,216	..	Do.
Do. .	(301) Messrs. Newbery and Ward.	Do. .	P. L. (renewal).	121·6	11th October 1926.	Do.
Do. .	(302) Do. .	Do. .	P. L. (renewal).	300·8	Do. .	Do.
Do. .	(303) Kim Swe . .	Do. .	P. L. (renewal).	396·8	31st November 1926.	Do.
Do. .	(304) Messrs. The Tavoy Tin Dredging Corporation, Ltd.	Do. .	P. L. (renewal).	3,033·6	30th January 1927.	Do.
Do. .	(305) Do. .	Do. .	P. L. (renewal).	1,196·8	27th February 1927.	Do.
Do. .	(306) Quah Cheng Tock.	Do. .	P. L. (renewal).	512	10th July 1927.	Do.
Do. .	(307) Mr. J. J. A. Page.	Do. .	P. L. (renewal).	217·6	12th July 1927.	Do.
Do. .	(308) Mr. C. W. Ross .	Do. .	P. L. (renewal).	1,011·2	3rd July 1927.	Do.
Do. .	(309) Maung Ba Oh .	Do. .	P. L. (renewal).	320	13th August 1927.	Do.
Do. .	(310) Maung E. Zin .	Do. .	P. L. (renewal).	723·2	26th August 1927.	Do.
Do. .	(311) Maung Po Swe .	Do. .	P. L. (renewal).	640	7th September 1927.	6 months.
Thaton .	(312) Mr. A. Rahim .	All minerals except oil.	P. L. .	2,444·8	7th February 1927.	1 year.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Thaton .	(313) Mr. J. M. Forsters.	All minerals except oil.	P. L. .	1,548·8	7th March 1927.	1 year.
Do. .	(314) Mr. A. C. Martin	Do. .	P. L. .	2·5	20th February 1927.	Do.
Do. .	(315) C. Chan Shwe .	Do. .	P. L. .	640	14th March 1927.	Do.
Do. .	(316) K. Beng Chong .	Do. .	P. L. .	755·2	24th August 1927.	Do.
Do. .	(317) Mr. A. C. Martin	Do. .	P. L. .	7,040	16th September 1927.	Do.
Thayetmyo.	(318) Mr. Ismail Abu Ahmed.	Natural petroleum	P. L. (renewal).	2,390	15th January 1927.	Do.
Do. .	(319) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. .	P. L. (renewal).	8,960	9th February 1927.	Do.
Do. .	(320) Messrs. The Indo-Burma Oilfields, Ltd.	Do. .	P. L. (renewal).	634·6	2nd January 1927.	Do.
Do. .	(321) Do. .	Do. .	P. L. (renewal).	640	29th March 1927.	Do.
Do. .	(322) Do. .	Do. .	P. L. (renewal).	6,400	28th April 1927.	Do.
Do. .	(323) Do. .	Do. .	P. L. (renewal).	2,560	12th July 1927.	Do.
Do. .	(324) Do. .	Do. .	P. L. (renewal).	960	22nd July 1927.	Do.
Do. .	(325) Messrs. The Burma Oil Co., Ltd.	Do. .	P. L. (renewal).	2,924·8	29th November 1927.	Do.
Do. .	(326) Messrs. The Indo-Burma Oilfields, Ltd.	Do. .	P. L. .	2,560	12th July 1926.	Do.
Do. .	(327) Do. .	Do. .	P. L. .	960	22nd July 1926.	Do.
Do. .	(328) U. Kyauk Lon .	Do. .	P. L. .	96	6th July 1927.	2 years.
Do. .	(329) Mg. Tun Yan .	Do. .	P. L. .	96	22nd November 1927.	1 year.
Toungoo .	(330) Mr. J. M. Forster	All minerals except natural petroleum.	P. L. .	1,280	15th February 1928.	Do.
Upper Chindwin.	(331) Messrs. The Burma Oil Co., Ltd.	Natural petroleum (including natural gas).	P. L. .	8,320	..	Do.
Do. .	(332) Do. .	Do. .	P. L. (renewal).	1,760	28th August 1927.	Do.
Do. .	(333) Messrs. The Coal Fields of Burma, Ltd.	Coal . . .	P. L. (renewal).	704	19th June 1926.	2 years.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Upper Chindwin.	(334) Messrs. The Indo-Burma Petroleum Co., Ltd.	Natural petroleum (including natural gas).	P. L. (renewal).	2,560	17th March 1927.	1 year.
Do.	(335) Messrs. The Indo-Burma Oilfields, Ltd.	Do.	P. L. (renewal).	3,200	11th July 1927.	Do.
Do.	(336) Messrs. The Coal Fields of Burma, Ltd.	Coal	P. L. (renewal).	678·4	3rd March 1927.	2 years.
Do.	(337) Do.	Do.	P. L. (renewal).	665·6	Do.	Do.
Do.	(338) Messrs. The Indo-Burma Petroleum Co., Ltd.	Natural petroleum (including natural gas).	P. L. (renewal).	640	6th October 1927.	1 year.

CENTRAL PROVINCES.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat	(339) Pandit Rewashankar.	Manganese	M. L.	4	3rd May 1927	10 years.
Do.	(340) Mr. Chandanlal	Do.	M. L.	250	11th December 1926.	20 years.
Do.	(341) Mr. P. N. Oke	Do.	P. L.	59	12th January 1927.	1 year.
Do.	(342) Mr. Kanhaiyalal	Do.	P. L.	30	1st July 1927	Do.
Do.	(343) Messrs. Nosharwanji and Ardeshir Brothers.	Do.	M. L.	10	18th December 1926.	10 years.
Do.	(344) Mr. M. A. Pasha	Do.	P. L.	43	18th March 1927.	1 year.
Do.	(345) Nawab Neazuddin Khan.	Do.	P. L.	69	2nd May 1927	Do.
Do.	(346) Do.	Do.	P. L.	14	Do.	Do.
Do.	(347) Do.	Do.	P. L.	56	4th October 1927.	Do.
Do.	(348) Do.	Do.	P. L.	81	2nd May 1927	Do.
Do.	(349) Mr. Kanhaiyalal	Do.	P. L.	7	15th June 1927.	Do.
Do.	(350) Pandit Kripashankar.	Do.	M. L.	126	30th December 1926.	30 years.
Do.	(351) Ramchandra Patel and Company.	Do.	P. L.	80	12th January 1927.	1 year.
Do.	(352) Pandit Kripashankar.	Do.	M. L.	32	7th February 1927.	30 years.
Do.	(353) Seth Bhudarsao.	Do.	P. L.	17	3rd May 1927	1 year.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(354) Mr. Kanhaiyalal	Manganese .	P. L. .	81	18th January 1927.	1 year.
Do. .	(355) Do. .	Do. . .	P. L. .	133	8th March 1927.	Do.
Do. .	(356) Do. .	Do. . .	P. L. .	497	Do.	Do.
Do. .	(357) Mr. Chandanlal .	Do. . .	P. L. .	4	8th April 1927.	Do.
Do. .	(358) Mr. C. S. Harris	Do. . .	M. L. .	3	14th February 1927.	30 years.
Do. .	(359) Mr. Samiulla Khan.	Do. . .	P. L. .	177	7th January 1924.	1 year.
Do. .	(360) Messrs. B. P. Byramji.	Do. . .	M. L. .	1	9th November 1927.	5 years.
Do. .	(361) Mr. Amritlal P. Trivedi.	Do. . .	P. L. .	52	2nd March 1927.	1 year.
Do. .	(362) Rai Bahadur Sir Bissessardas Daga.	Do. . .	M. L. .	77	2nd September 1927.	5 years.
Do. .	(363) Mr. Amritlal P. Trivedi.	Do. . .	P. L. .	10	8th March 1927.	1 year.
Do. .	(364) Nawab Neazuddin Khan.	Do. . .	M. L. .	12	4th July 1927	20 years.
Do. .	(365) Mr. P. N. Oke .	Do. . .	P. L. .	8	21st January 1927.	1 year.
Do. .	(366) Messrs. Nosharwanji and Ardeshir Brothers.	Do. . .	P. L. .	16	31st August 1927.	Do.
Do. .	(367) The Nagpur Manganese Mining Syndicate.	Do. . .	M. L. . .	17	22nd July 1927.	10 years.
Do. .	(368) Mr. Chandanlal	Do. . .	P. L. .	44	26th September 1927.	1 year.
Do. .	(369) Mr. Amritlal P. Trivedi.	Do. . .	P. L. .	92	21st February 1927.	Do.
Do. .	(370) Messrs. Khoja Mitha Bhai Nathoo.	Do. . .	P. L. .	175	14th March 1927.	Do.
Do. .	(371) Seth Bhopat Rao.	Do. . .	P. L. .	279	4th July 1927	Do.
Do. .	(372) Seth Permanand Bansidhar.	Do. . .	M. L. .	1	14th April 1927.	30 years.
Do. .	(373) Messrs. S. Laxman Rao and B. Narsingrao.	Do. . .	P. L. .	25	12th February 1927.	1 year.
Do. .	(374) Seth Shreeram .	Do. . .	M. L. .	35	27th June 1927.	5 years.
Do. .	(375) Mr. Amritlal P. Trivedi.	Do. . .	P. L. .	3	9th April 1927.	1 year.
Do. .	(376) Messrs. Khoja Mitha Bhai Nathoo.	Do. . .	P. L. .	26	30th July 1927.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(377) The Indian Manganese Company, Ltd.	Manganese .	P. L. .	850	18th April 1927.	1 year.
Do. .	(378) Messrs. Ramnath Baijnath Sao Rusia.	Do. . .	M. L. .	17	29th October 1927.	30 years.
Do. .	(379) The Central India Mining Company, Ltd.	Do. . .	P. L. .	806	21st June 1927.	1 year.
Do. .	(380) Mr. C. S. Harris	Limestone . .	P. L. .	10	2nd May 1927.	Do.
Do. .	(381) Mr. Amritlal P. Trivedi.	Manganese . .	P. L. .	37	9th April 1927.	Do.
Do. .	(382) Messrs. B. P. Byramji and Company.	Do. . .	P. L. .	538	13th October 1927.	Do.
Do. .	(383) Mr. Amritlal P. Trivedi.	Do. . .	P. L. .	137	28th April 1927.	Do
Do. .	(384) Thakur Narsib Singh.	Do. . .	P. L. .	350	14th May 1927.	Do
Do. .	(385) Mr. Amritlal P. Trivedi.	Do. . .	P. L. .	30	9th April 1927.	Do
Do. .	(386) Musst. Munna Bai.	Do. . .	P. L. .	36	16th September 1927.	Do.
Do. .	(387) Mr. Samiulla Khan.	Do. .	P. L. .	370	20th July 1927.	Do.
Do. .	(388) Musst. Munna Bai.	Do. . .	P. L. .	156	16th September 1927.	Do.
Do. .	(389) Do. .	Do. . .	P. L.	105	30th May 1927.	Do.
Do. .	(390) Mr. Amritlal P. Trivedi.	Do. . .	P. L. .	74	5th June 1927.	Do.
Do. .	(391) R. B. Chhajuram.	Do. . .	P. L.	241	23rd June 1927.	Do.
Do. .	(392) Thakur Nasib Singh.	Do. . .	P. L. .	246	18th July 1927.	Do.
Do. .	(393) Mr. B. V. Buti .	Do. . .	P. L. .	197	20th July 1927.	Do.
Do. .	(394) Mr. Amritlal P. Trivedi.	Do. . .	M. L. .	35	12th September 1927.	5 years.
Do. .	(395) Musst. Munna Bai.	Do. . .	P. L. .	30	13th August 1927.	1 year.
Do. .	(396) Mr. Bhawanji Naranji.	Do. . .	P. L. .	328	21st October 1927.	Do.
Do. .	(397) Musst. Munna Bai.	Do. . .	P. L. .	132	16th September 1927.	Do.
Do. .	(398) Mr. M. B. Marfatia.	Do. . .	M. L. .	15	14th October 1927.	30 years.
Do. .	(399) Mr. Samiulla Khan.	Do. . .	P. L. .	76	26th September 1927.	1 year.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

F

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(400) Musst. Munna Bai.	Manganese . .	P. L. .	43	18th August 1927.	1 year.
Do. .	(401) Mr. Bhawanji Naranji.	Do. . .	P. L. .	184	12th September 1927.	Do.
Do. .	(402) Mr. Amritlal P. Trivedi.	Do. . .	P. L. .	29	21st August 1927.	Do.
Do. .	(403) Musst. Munna Bai.	Do. . .	P. L. .	74	7th July 1927.	Do.
Do. .	(404) The Central India Mining Company, Ltd.	Do. . .	P. L. .	70	22nd July 1927.	Do.
Do. .	(405) Do. .	Do. . .	P. L. .	150	Do.	Do.
Do. .	(406) Do. .	Do. . .	P. L. .	124	Do.	Do.
Do. .	(407) Do. .	Do. . .	P. L. .	301	3rd December 1927.	Do.
Do. .	(408) Nawab Neazuddin Khan.	Do. . .	P. L. .	109	6th December 1927.	Do.
Do. .	(409) Do. .	Do. . .	P. L. .	19	Do.	Do.
Do. .	(410) Mr. Mohammad Anwar Pasha.	Do. . .	P. L. .	16	7th October 1927.	Do.
Do. .	(411) Messrs. B. P. Byramji and Company.	Do. . .	P. L. .	176	1st July 1927.	Do.
Do. .	(412) Mr. Samiulla Khan	Do. . .	P. L. .	171	24th August 1927.	Do.
Do. .	(413) Seth Ganeshlal Balbhadra.	Do. . .	P. L. .	293	9th September 1927.	Do.
Do. .	(414) Messrs. Lalbehari Ramcharan.	Do. . .	P. L. .	39	12th October 1927.	Do.
Do. .	(415) Mr. C. S. Harris	Do. . .	P. L. .	14	18th July 1927.	Do.
Do. .	(416) Mr. Amritlal P. Trivedi.	Do. . .	M. L. .	42	27th September 1927.	15 years.
Do. .	(417) Do. .	Do. . .	P. L. .	19	21st August 1927.	1 year.
Do. .	(418) Messrs. B. P. Byramji and Company.	Do. . .	P. L. .	99	4th August 1927.	Do.
Do. .	(419) Mr. Amritlal P. Trivedi.	Do. . .	P. L. .	47	6th August 1927.	Do.
Do. .	(420) Mr. Samiulla Khan.	Do. . .	P. L. .	12	27th September 1927.	Do.
Do. .	(421) Mr. Amritlal P. Trivedi.	Do. . .	P. L. .	24	21st October 1927.	Do.
Do. .	(422) Do. .	Do. . .	P. L. .	25	21st August 1927.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat	(423) Mr. P. N. Oke	Manganese	P. L.	78	25th August 1927.	1 year.
Do.	(424) Mr. Kanhaiyalal	Do.	P. L.	27	5th November 1927.	Do.
Do.	(425) Messrs. B. P. Byramji and Company.	Do.	M. L.	6	24th November 1927.	5 years.
Do.	(426) Mr. Amritlal P. Trivedi.	Do.	P. L.	39	21st October 1927.	1 year.
Do.	(427) Mr. Abdul Rahim Khan.	Do.	P. L.	156	26th October 1927.	Do.
Do.	(428) Mr. Amritlal P. Trivedi.	Do.	M. L.	16	29th October 1927.	10 years.
Do.	(429) Do.	Do.	P. L.	65	18th November 1927.	1 year.
Do.	(430) The Indian Manganese Co., Ltd.	Do.	P. L.	69	17th December 1927.	Do.
Do	(431) Do.	Do.	P. L.	19	5th November 1927.	Do.
Do.	(432) Pandit Kripasankar	Do.	M. L.	70	22nd December 1927.	29 years.
Betul	(433) Pandit Kashiram, P. W. D. and Railway Contractor, Shahpur.	Coal	P. L.	634	27th June 1927.	Do.
Bhandara	(434) Nawab Neazuddin Khan.	Manganese	P. L.	196	23rd April 1927.	Do.
Do.	(435) Do.	Do.	P. L.	85	7th May 1927.	Do.
Do.	(436) Messrs. Namdeo Pandurang Dalal and others.	Do.	P. L.	263	6th May 1927.	Do.
Do.	(437) Mr. Samiulla Khan.	Do.	P. L.	150	Extended till the execution of the mining lease.	..
Do.	(438) Mr. P. N. Oke	Do.	P. L.	69	29th March 1927.	1 year.
Do.	(439) Mr. Ganeshlal Balbhadra.	Do.	P. L.	15	16th April 1927.	Do.
Do.	(440) Mr. Sheopratap Kalachand Marwadi.	Do.	P. L.	84	31st October 1927.	Do.
Do.	(441) Messrs. Nilkant Sao and Company.	Do.	P. L.	24	24th February 1927.	Do.
Do.	(442) Mr. Suresh Chandra Das Gupta.	Do.	P. L.	125	6th April 1927.	Do.
Do.	(443) Messrs. Nilkant Sao and Company.	Do.	P. L.	38	19th April 1927.	Do.
Do.	(444) Do.	Do.	P. L.	99	Do.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara .	(445) Messrs. Namdeo Pandurang Dalal and others.	Manganese .	P. L. .	106	6th June 1927.	1 year.
Do. .	(446) Do. .	Do. . .	P. L. .	65	6th May 1927	Do.
Do. .	(447) Do. .	Do. . .	P. L. .	570	9th October 1927.	Do.
Do. .	(448) Mr. A. C. Maitra	Do. . .	P. L. .	342 .	23rd July 1927.	Do.
Do. .	(449) Mr. M. A. Pasha	Do. . .	P. L. .	8	19th April 1927.	Do.
Do. .	(450) Messrs. Ganpatsao Dhanpatsao.	Do. . .	P. L. .	40	24th June 1927.	Do.
Do. .	(451) Rai Bahadur Nritya Gopal Bose, Pleader.	Do. . .	P. L. .	58	20th October 1927.	Do.
Do. .	(452) Mr. Shriram Seth.	Do. . .	P. L. .	8	5th August 1927.	Do.
Do. .	(453) Rai Bahadur Nritya Gopal Bose, Pleader.	Do. . .	P. L. .	176	20th October 1927.	Do.
Do. .	(454) Nawab Neazuddin Khan.	Do. . .	P. L. .	16	27th September 1927.	Do.
Do. .	(455) Messrs. Ganeshlal Balbhadra.	Do. . .	P. L. .	13	13th October 1927.	Do.
Do. .	(456) Rai Sahib Gowardhandas.	Do. . .	P. L. .	113	20th October 1927.	Do.
Do. .	(457) Messrs. Jadulal Bhadulal.	Do. . .	P. L. .	48	10th December 1927.	Do.
Do. .	(458) Rai Sahib Gowardhandas.	Do. . .	P. L. .	4	20th October 1927.	Do.
Do. .	(459) Ramchandra Patil and Company.	Do. . .	P. L. .	91	30th November 1927.	Do.
Do. .	(460) Mr. M. A. Pasha	Do. . .	P. L. .	100	27th December 1927.	Do.
Do. .	(461) Messrs. Yadulal Bhadulal.	Do. . .	P. L. .	1	25th December 1927.	Do.
Do. .	(462) Mr. S. Allimuddin.	Do. . .	P. L. .	61	7th December 1927.	Do.
Do. .	(463) Lala Jainarayan Mohanlal.	Do. . .	M. L. .	34	5th April 1927.	5 years.
Do. .	(464) Rai Sahib Seth Gowardhan Dass.	Do. . .	M. L. .	7	9th February 1927.	10 years.
Do. .	(465) Messrs. Nilkant Sao and Company.	Do. . .	M. L. .	18	20th April 1927.	20 years.
Do. .	(466) Messrs. Ganpatsao Dhanpatsao.	Do. . .	M. L. .	19	14th September 1927.	6 years.
Do. .	(467) Messrs. Ganeshlal Balbhadra.	Do. . .	M. L. .	19	6th October 1927.	5 years.

P.L.—*Prospecting License.* M. L.—*Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara .	(468) Messrs. Nilkant Sao and Company.	Manganese .	M. L. .	27	29th July 1927.	30 years.
Do. .	(469) Mr. Shriram Seth	Do. . .	M. L. .	15	24th November 1927.	5 years.
Bilaspur .	(470) Messrs. Agarwala Brothers.	Do. . .	P. L. .	200	16th February 1927.	1 year.
Do. .	(471) Messrs. Dunlop and Considine (Ghardama Coal Fields Ltd.).	Coal and iron .	P. L. .	11,900	9th March 1927.	Do.
Do. .	(472) Do. .	Coal . .	P. L. .	12,256	1st July 1927	Do.
Do. .	(473) Do. .	Do. . . .	P. L. .	3,376	6th November 1927.	Do.
Do. .	(474) Do. .	Do. . . .	P. L. .	4,324	30th November 1927.	Do.
Do. .	(475) Messrs. Natham Brothers.	Do. . . .	P. L. .	338	2nd December 1927.	Do.
Chhindwara	(476) Seth Laxminarayan Hasdeo.	Manganese . .	P. L. .	433	7th May 1927	Do.
Do. .	(477) Mr. A. V. Wazalwar, Pleader.	Do. . .	P. L. .	71	12th March 1927.	Do.
Do. .	(478) Mr. Noor Mohammad Mitha.	Do. . .	P. L. .	329	6th December 1927.	Do.
Do. .	(479) Nawab Niazuddin.	Do. . .	P. L. .	37	28th June 1927.	Do.
Do. .	(480) Messrs. Chaitram Sao and Tikaram Sao.	Do. . .	P. L. .	315	21st June 1927.	Do.
Do. .	(481) Mr. Pratul Narain Mukerji.	Coal . . .	P. L. .	241	5th April 1927.	Do.
Do. .	(482) Mr. Hussain Khan.	Manganese . .	P. L. .	275	3rd January 1927.	Do.
Do. .	(483) Mr. Saimulla Khan.	Do. . .	P. L. .	105	12th February 1927.	Do.
Do. .	(484) Nawab Niazuddin Khan.	Do. . .	P. L. .	88	25th July 1927.	Do.
Do. .	(485) H. S. Zahiruddin	Coal . . .	P. L. .	198	19th February 1927.	Do.
Do. .	(486) Mr. Hussain Khan.	Manganese . .	P. L. .	203	17th January 1927.	Do.
Do. .	(487) Do. .	Do. . .	P. L. .	74	Do. .	Do.
Do. .	(488) Mr. Samiulla Khan.	Do. . .	P. L. .	222	12th February 1927.	Do.
Do. .	(489) Mr. Komalchand Jain.	Do. . .	P. L. .	5	11th May 1927.	Do.
Do. .	(490) Messrs. Gopaldas and Nemalchand.	Do. . .	P. L. .	242	18th May 1927.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara	(491) Messrs. Gopaldas and Nemaichand.	Manganese . .	P. L. .	257	18th May 1927.	1 year.
Do. .	(492) Do. .	Do. . .	P. L. .	106	Do. .	Do.
Do. .	(493) Thakur Randhir Shah, Jagirdar.	Coal . . .	P. L. .	146	19th January 1927.	Do.
Do. .	(494) Do. .	Do. . . .	P. L. .	443	25th March 1927.	Do.
Do. .	(495) Newton Chikhli Colliery.	Do. . . .	P. L. .	820	18th February 1927.	Do.
Do. .	(496) Shrimant B. P. Buti.	Do. . . .	P. L. .	234	22nd June 1927.	Do.
Do. .	(497) Mr. Hussain Khan.	Manganese . .	P. L. .	59	18th May 1927.	Do.
Do. .	(498) Mr. F. L. S. Simpson.	Do. . .	P. L. .	517	25th March 1927.	Do.
Do. .	(499) Mr. Komalchand Jain.	Do. . .	P. L. .	10	11th May 1927.	Do.
Do. .	(500) Mr. Hussain Khan.	Do. . .	P. L. .	128	16th February 1927.	Do.
Do. .	(501) Mr. R. P. Mudaliar, Proprietor of the Independent Trading Company.	Do. . .	P. L. .	180	16th September 1927.	Do.
Do. .	(502) Mr. Hussain Khan.	Do. . .	P. L. .	54	8th August 1927.	Do.
Do. .	(503) Mr. K. C. Gupta	Do. . .	P. L. .	76	1st September 1927.	Do.
Do. .	(504) S. Laxman Rao and B. Narsingh Rao Naidu.	Do. . .	P. L. .	125	29th October 1927.	Do.
Do. .	(505) Mr. Hussain Khan.	Coal . . .	P. L. .	580	Do. .	Do.
Do. .	(506) Messrs. B. Fouzdar and Brothers.	Mica . . .	P. L. .	101	21st December 1927.	Do.
Drug . .	(507) Nawab Niazuddin Khan.	Galena . .	P. L. .	132	30th August 1927.	Do.
Do. .	(508) Mr. Laxminarayan Hardeo.	Do. . .	M. L. .	14	3rd November 1927.	5 years.
Jubbulpore.	(509) Mr. P. C. Dutt, Nagpur.	Manganese . .	M. L. .	4	25th February 1927.	28 years.
Do. .	(510) Mr. M. Venkat Ramanna, Katni.	Do. . .	P. L. .	144	31st March 1927.	1 year.
Do. .	(511) Do. .	Do. . .	P. L. .	219	Do. .	Do.
Do. .	(512) Do. .	Bauxite . .	P. L. .	26	25th May 1927.	Do.
Do. .	(513) Mr. C. Stanley Harris, Balaghat.	Do. . .	P. L. .	75	5th January 1927.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore .	(514) M. C. Stanley Harris, Balaghat.	Bauxite . .	P. L. .	74	5th January 1927.	1 year.
Do. .	(515) Pandit Chakori Lall Pathak.	Do. . .	P. L. .	3	16th March 1927.	Do.
Do. .	(516) Mr. C. Stanley Harris, Balaghat.	Manganese . .	M. L. .	50	13th July 1927.	30 years.
Do. .	(517) Mr. N. Venkat Ramanna, Katni.	Bauxite . .	P. L. .	226	20th July 1927.	1 year.
Nagpur .	(518) Messrs. Ganpatsao Dhanpatsao.	Manganese . .	P. L. .	39	9th August 1927.	Do.
Do. .	(519) Mr. M. A. Razaq	Do. . .	M. L. . (Supplementary).	31	30th July 1927.	4 years.
Do. .	(520) Do. .	Do. . .	P. L. .	59	23rd June 1927.	1 year.
Do. .	(521) Mr. Shamji Narainji.	Do. . .	P. L. .	39	3rd January 1927.	Do.
Do. .	(522) Mr. Noor Mohamad Metha.	Do. . .	M. L. .	119	25th January 1927.	30 years.
Do .	(523) Seth Raghunath Das Bharuka.	Do. . .	M. L. .	41	21st January 1927.	10 years.
Do. .	(524) Mr. Noor Mohamad Metha.	Do. . .	M. L. .	494	1st April 1927.	30 years.
Do. .	(525) Do. .	Do . .	M. L. .	182	25th January 1927.	Do.
Do. .	(526) Mr. M. A. Razaq	Do. . .	P. L. .	13	8th February 1927.	1 year.
Do. .	(527) Mr. S. Vinayak Rao.	Do. . .	P. L. .	45	31st January 1927.	Do.
Do. .	(528) Mr. Noor Mohamad Metha.	Do. . .	P. L. .	574	21st September 1927.	Do.
Do. .	(529) Mr. M. A. Razaq	Do. . .	P. L. .	10	12th April 1927.	Do.
Do. .	(530) Do. .	Do. . .	P. L. .	135	19th August 1927.	Do.
Do. .	(531) The Berar Mining Association.	Do. . .	P. L. .	213	19th March 1927.	Do.
Do. .	(532) Mr. M. A. Razaq	Do. . .	P. L. .	120	24th June 1927	Do.
Do .	(533) Do. .	Do. . .	P. L. .	82	23rd June 1927.	Do.
Do. .	(534) The Berar Mining Association.	Do. . .	P. L. .	45	19th March 1927.	Do.
Do. .	(535) Do. .	Do. . .	P. L. .	86	20th June 1927.	Do.
Do. .	(536) Mr. L. D. Lele .	Do. . .	P. L. .	308	20th July 1927.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(537) Mr. A. V. Wasa-war.	Manganese . .	P. L. .	189	16th February 1927.	1 year.
Do. .	(538) Mr. B. D. Vyas .	Do. . .	P. L. .	49	4th February 1927.	Do.
Do. .	(539) Seth Ramkrishna Ramnath.	Do. . .	P. L. .	37	13th January 1927.	Do.
Do. .	(540) The Berar Mining Association	Do. . .	P. L. .	600	4th June 1927.	Do.
Do. .	(541) Mr M. A. Razaq	Do. . .	P. L. .	148	23rd June 1927.	Do.
Do. .	(542) Mr. L. D. Lele .	Do. . .	P. L. .	160	8th February 1927.	Do.
Do. .	(543) K. S. Mohamad Yakub.	Do. . .	P. L. .	67	22nd January 1927.	Do.
Do. .	(544) Messrs. Bholanath Das and Company.	Do. . .	P. L. .	68	29th January 1927.	Do.
Do. .	(545) Sir Hari Singh Gour.	Do. . .	P L. .	651	4th February 1927.	Do.
Do. .	(546) Mr. M. A. Razaq	Do. . .	P. L. .	70	12th April 1927.	Do.
Do. .	(547) Messrs. Bholanath Das and Company.	Do . .	P. L. .	42	29th January 1927.	Do.
Do. .	(548) Do. .	Do. . .	P. L. .	160	1st April 1927.	Do.
Do. .	(549) Mr. Bhawanji Narainji.	Do. . .	P. L. .	128	29th March 1927.	Do.
Do. .	(550) Mr. M. A. Razaq	Do. . .	P. L. .	31	12th January 1927.	Do.
Do. .	(551) Mr. Mangal Singh.	Do. . .	P. L. .	134	13th January 1927.	Do.
Do. .	(552) Seth Ramkrishna Ramnath.	Do. . .	P. L. .	12	22nd January 1927.	Do.
Do. .	(553) Messrs. Murlidhar and Budhulal.	Do. . .	P. L. .	100	1st February 1927.	Do.
Do. .	(554) Do. . .	Do. . .	P. L. .	83	Do.	Do.
Do. .	(555) Mr. Bhowanji Narainji.	Do. . .	P. L. .	98	16th September 1927.	Do.
Do. .	(556) Sir Maneckjee B. Dadabhoy.	Do. . .	P. L. .	121	29th June 1927.	Do.
Do. .	(557) Mr. G. R. Totade	Do. . .	P. L. .	157	13th April 1927.	Do.
Do .	(558) Thakur Kisan Singh.	Do. . .	P. L. .	64	12th May 1927.	Do.
Do. .	(559) Mr. Bhawanji Narainji.	Do. . .	P. L. .	39	3rd January 1927.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(560) Sir Manockjee B. Dadabhoy.	Manganese	P. L.	37	26th April 1927.	1 year.
Do.	(561) Messrs. The Independent Trading Co.	Do.	P. L.	96	13th June 1927.	Do.
Do.	(562) Mr. Mayal Singh	Do.	P. L.	66	14th April 1927.	Do.
Do.	(563) Do.	Do.	P. L.	218	13th April 1927.	Do.
Do.	(564) Do.	Do.	P. L.	64	19th April 1927.	Do.
Do.	(565) Do.	Do.	P. L.	60	8th March 1927.	Do.
Do.	(566) Messrs. M. D. Zal & Bros.	Do.	P. L.	43	9th May 1927	Do.
Do.	(567) Do.	Do.	P. L.	67	30th July 1927.	Do.
Do.	(568) Mr. Bhawanji Narainji.	Do.	P. L.	31	5th March 1927.	Do.
Do.	(569) Mr. S. C. Dass Gupta.	Do.	P. L.	165	29th March 1927.	Do.
Do.	(570) Mr. N. G. Bose	Do.	P. L.	26	29th January 1927.	Do.
Do.	(571) Mr. Mangal Singh.	Do.	P. L.	65	30th March 1927.	Do.
Do.	(572) Mr. Shamji Narainji.	Do.	P. L.	28	3rd January 1927.	Do.
Do.	(573) Mr. Mangal Singh.	Do.	P. L.	26	7th January 1927.	Do.
Do.	(574) Messrs. Murlidhar and Budhulal.	Do.	P. L.	228	18th August 1927.	Do.
Do.	(575) Messrs. C. Harmosji and N. Rustumji.	Do.	P. L.	253	3rd January 1927.	Do.
Do.	(576) Do.	Do.	P. L.	41	Do.	Do.
Do.	(577) Do.	Do.	P. L.	115	8th April 1927.	Do.
Do.	(578) Nawab Neazuddin Khan.	Do.	P. L.	249	7th October 1927.	Do.
Do.	(579) Mr. Mangal Singh.	Do.	P. L.	62	29th July 1927.	Do.
Do.	(580) Messrs. C. Harmosji and N. Rustumji.	Do.	P. L.	38	24th March 1927.	Do.
Do.	(581) Mr. Bhawanji Narainji.	Do.	P. L.	117	14th July 1927.	Do.
Do.	(582) Messrs. Kar & Co.	Do.	P. L.	450	11th May 1927.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(583) Messrs. C. Harmosji and N. Rustumji.	Manganese .	P. L. .	8	8th April 1927.	1 year.
Do. .	(584) Do. .	Do. . .	P. L. .	56	24th March 1927.	Do.
Do. .	(585) Do.	Do. . .	P. L. .	442	16th September 1927.	Do.
Do. .	(586) Mr. Bhawanji Narainji.	Do. . .	P. L. .	56	17th October 1927.	Do.
Do. .	(587) Do. .	Do. . .	P. L. .	63	15th August 1927.	Do.
Do. .	(588) Messrs. Ganpatsao Dhanpatsao.	Do. . .	P. L. .	39	19th August 1927.	Do.
Do. .	(589) Do. .	Do. . .	P. L. .	10	8th March 1927.	Do.
Do. .	(590) Do. .	Do. . .	P. L. .	134	Do.	Do.
Do. .	(591) Nawab Neazuddin Khan.	Do. . .	P. L. .	37	7th October 1927.	Do.
Do. .	(592) Mr. Khoja Mithabhai Nath.	Do. . .	P. L. .	35	29th July 1927.	Do.
Do. .	(593) Messrs. Nosherwanji Ardeshir Brothers.	Do. . .	M. L. .	7	15th February 1927.	30 years.
Do. .	(594) Seth Kisandayal Labhuchand.	Do. . .	M. L. .	50	27th October 1927.	15 years.
Do. .	(595) Mr. Syed Rasul	Do. . .	M. L. .	168	4th March 1927.	30 years.
Do. .	(596) Mr. Moheshpuri	Do. . .	M. L. .	37	14th February 1928.	10 years.
Do. .	(597) Mr. Shamji Narainji.	Do. . .	M. L. .	27	31st January 1927.	15 years.
Do. .	(598) Mr. Syed Hifzul Raquib.	Do. . .	M. L. .	58	16th March 1927.	Do.
Do. .	(599) Mr. S. Vinayak Rao.	Do. . .	M. L. .	16	14th April 1927.	30 years.
Do. .	(600) Seth Shrikisan Hazarimal.	Do. . .	M. L. .	4	23rd May 1927.	3 years.
Do. .	(601) Messrs. Namdeo Sao Dalal & Co.	Do. . .	M. L. .	60	5th April 1927.	1 year.
Do. .	(602) Mr. G. R. Tolade	Do. . .	M. L. .	15	10th May 1927.	5 years.
Do. .	(603) Mr. Akbar Ali .	Do. . .	M. L. .	29	1st March 1927.	Do.
Do. .	(604) Mr. Moheshpuri	Do. . .	M. L. .	83	14th February 1927.	10 years.
Do. .	(605) Mr. M. A. Razaq	Do. . .	M. L. .	21	16th November 1927.	4 years and 14 days.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(606) The Central India, Mining Co. Ltd.	Manganese . .	P. L. .	160	10th October 1927.	1 year.
Do. .	(607) Seth Jagannath	Do. . .	P. L. .	108	16th September 1927.	Do.
Do. .	(608) Nawab Neazud-din Khan.	Do. . .	P. L. .	158	6th July 1927	Do.
Do. .	(609) Mr. Shamji Narainji.	Do. . .	P. L. .	55	6th December 1927.	Do.
Do. .	(610) Mr. Bhawanji Narainji.	Do. . .	P. L. .	59	17th October 1927.	Do.
Do. .	(611) Mr. Shamji Narainji.	Do. . .	P. L. .	182	17th October 1927.	Do.
Do. .	(612) Messrs. Ganpatsao Dhanpatsao.	Do. . .	P. L. .	66	18th August 1927.	Do.
Do. .	(613) Seth Jagannath	Do. . .	P. L. .	21	14th July 1927.	Do.
Do. .	(614) Nawab Neazud-din Khan.	Do. . .	P. L. .	156	7th October 1927.	Do.
Do. .	(615) Do. .	Do. . .	P. L. .	113	2nd September 1927.	Do.
Do. .	(616) Do. .	Do. . .	P. L. .	135	22nd July 1927.	Do.
Do. .	(617) Mr. Bhawanji Narainji.	Do. . .	P. L. .	55	17th October 1927.	Do.
Do. .	(618) Mr. Syed Hifzul Raquib.	Do. . .	P. L. .	131	29th April 1927.	Do.
Do. .	(619) Mr. Yadulal Bhodulal.	Do. . .	P. L. .	129	16th September 1927.	Do.
Do. .	(620) Thakur Kisan Singh.	Do. . .	P. L. .	112	2nd August 1927.	Do.
Do. .	(621) Nawab Neazud-din Khan.	Do. . .	P. L. .	123	2nd September 1927.	Do.
Do. .	(622) Seth Gopaldas Nemichand.	Do. . .	P. L. .	185	17th October 1927.	Do.
Do. .	(623) Mr. Mangal Singh	Do. . .	P. L. .	74	29th July 1927.	Do.
Do. .	(624) Mr. Shamji Narainji.	Do. . .	P. L. .	11	17th October 1927.	Do.
Do. .	(625) Mr. K. C. Gupta	Do. . .	P. L. .	532	17th June 1927.	Do.
Do. .	(626) Messrs. C. Harmosji and N. Rustumji.	Do. . .	P. L. .	56	16th September 1927.	Do.
Do. .	(627) Mr. Mangal Singh	Do. . .	P. L. .	40	13th July 1927.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(628) Mr. M. A. Razaq	Manganese .	P. L. .	227	22nd July 1927.	1 year.
Do. .	(629) Mr. Mangal Singh	Do. . .	P. L. .	116	29th April 1927.	Do.
Do. .	(630) Nawab Neazud-din Khan.	Do. . .	P. L. .	29	24th June 1927.	Do.
Do. .	(631) Do. .	Do. . .	P. L. .	7	Do. .	Do.
Do. .	(632) Messrs. C. Harmosji and N. Rustumji.	Do. . .	P. L. .	111	16th September 1927.	Do.
Do. .	(633) Do. .	Do. . .	P. L. .	10	15th September 1927.	Do.
Do. .	(634) Mr. Mangal Singh	Do. . .	P. L. .	100	14th October 1927.	Do.
Do.	(635) Mr. S. C. Das Gupta.	Do. . .	P. L. .	374	15th July 1927.	Do.
Do. .	(636) Mr. Mangal Singh	Do. . .	P. L. .	237	29th July 1927.	Do.
Do. .	(637) Sir Hari Singh Gour.	Do. . .	P. L. .	319	4th November 1927.	Do.
Do. .	(638) The Central India Mining Company, Ltd.	Do. . .	P. L. .	48	18th October 1927.	Do.
Do. .	(639) Mr. B. V. Buti .	Do. . .	P. L. .	68	21st September 1927.	Do.
Do. .	(640) Mr. Mangal Singh	Do. . .	P. L. .	148	11th November 1927.	Do.
Do. .	(641) Mr. Bhawanji Narainji.	Do. . .	P. L. .	15	17th October 1927.	Do.
Do. .	(642) Mr. Mangal Singh	Do. . .	P. L. .	141	11th November 1927.	Do.
Do. .	(643) Mr. K. C. Gupta	Do. . .	P. L.	50	28th September 1927.	Do.
Do. .	(644) Mr. Mangal Singh	Do. . .	P. L. .	37	14th July 1927.	Do.
Do. .	(645) Sir M. B. Dadabhoy.	Do. . .	P. L. .	110	5th December 1927.	Do.
Do. .	(646) Messrs. C. Harmosji and N. Rustumji.	Do. . .	P. L. .	73	15th November 1927.	Do.
Do. .	(647) Messrs. Ganpatsao Dhanpatsao.	Do. . .	M. L. .	19	9th November 1927.	20 years.
Do. .	(648) Messrs. Shamji Narainji.	Do. . .	M. L. . (Supplementary agreements)	1	21st April 1927.	1 year.
Do. .	(649) Mr. Maheshpuri	Do. . .	Do. .	59	9th May 1927	5 years.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

MADRAS.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bellary .	(650) Mr. K. A. Hye .	Manganese . .	M. L. .	1,503·16	20th January 1927.	30 years.
Do.	(651) Messrs. Oomer Salt & Co.	Do. . .	P. L. .	853·51	29th July 1927.	1 year.
Do. .	(652) The Managing Director, Sree Nageswara Mining Company.	Do. . .	P. L. .	71·90	28th April 1927.	Do.
Cuddapah .	(653) Mr. B. Sitaramachar.	Asbestos . .	P. L. .	184·53	9th May 1927	Do.
Do. .	(654) The Mysore Development Syndicate.	Do. . .	P. L. .	730·06	20th July 1927.	Do.
Do.	(655) Nabi Sahib .	Barytes . .	P. L. .	62·08	26th August 1927.	Do.
Kurnool .	(656) Mr. V. Venkata Subayya Pantulu.	Do. . .	P. L. .	2·48	7th June 1927.	Do.
Do. .	(657) Do. .	Do. . .	P. L. .	1·65	Do. .	Do.
Do. .	(658) D. Ashroff Hussain Khan.	Do. . .	P. L. .	34·29	16th February 1927.	Do.
Do. .	(659) Do. .	Do. . .	P. L. .	61·20	24th June 1927	Do.
Do. .	(660) Mr. V. Venkatasubbayya.	Do. . .	P. L. .	1·35	21st March 1927.	Do.
Do. .	(661) D. Ashroff Hussain Khan.	Do. . .	P. L. .	24·50	26th June 1927	Do.
Do. .	(662) Mr. B. P. Sesha Reddi.	Do. . .	P. L. .	5·20	6th December 1927.	Do.
Do. .	(663) Do. .	Do. . .	P. L. .	15·22	4th October 1927.	Do.
Nellore .	(664) Mr. B. Ramalingayya Chetti.	Mica . .	M. L. .	80·50	16th December 1926.	30 years.
Do. .	(665) Mr. Bangarayya Chetti.	Do. . .	M. L. .	391·18	2nd February 1927.	Do.
Do. .	(666) Mr. M. Dasaratharami Reddi.	Do. . .	M. L. .	33·32 31·88	16th December 1926.	Do.
Do. .	(667) Mr. M. Rama Rao	Do. . .	P. L. .	4·29	31st January 1927.	1 year.
Do. .	(668) Mr. A. Pitchayya Nayudu.	Do. . .	P. L. .	117·21	Do. .	Do.
Do. .	(669) Mr. S. Venkatasubba Nayudu.	Do. . .	M. L. .	21·80	19th February 1927.	30 years.
Do. .	(670) Do. .	Do. . .	M. L. .	50·61	16th March 1927.	Do.
Do. .	(671) Mr. Pathabhiram Reddi.	Do. . .	P. L. .	102·93	4th January 1927.	1 year.
Do. .	(672) Mr. G. Venkatachalam Chetti.	Do. . .	M. L. .	9·80	25th December 1926.	30 years.

P. L.—*Prospecting License.* M. L.—*Mining Lease.*

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore .	(673) Mr. R. Ramalingam Chetti.	Mica . .	M. L. .	32·14	9th March 1927.	30 years.
Do. .	(674) Mr. T. Ramasubba Reddi.	Do. . .	P. L. .	48·68	27th May 1927	1 year.
Do. .	(675) Mr. M. Rama Rao.	Do. . .	P. L. .	36·10	19th February 1927.	Do.
Do. .	(676) Mr. M. Dasaratharami Reddi.	Do. . .	M. L. .	0·43	1st April 1927.	30 years.
Do. .	(677) Mr. C. Venkatarami Chetti.	Do. . .	P. L. .	27·73	7th January 1927.	1 year.
Do. .	(678) Mr. G. Venkatachalam Chetti.	Do. . .	P. L. .	90·92	9th March 1927.	Do.
Do. .	(679) Mr. G. Venkatachalam Chetti.	Do. . .	P. L. .	20·90	19th February 1927.	Do.
Do. .	(680) Mr. C. Pattabhiramayya.	Do. . .	M. L. .	9·63	28th July 1927.	30 years.
Do. .	(681) Mr. G. Chenchusubba Reddi.	Do. . .	M. L. .	15·18	12th January 1927.	Do.
Do. .	(682) Mr. A. Rama Nayudu.	Do. . .	P. L. .	132·31	5th November 1927.	1 year.
Do. .	(683) Mr. A. Sankarayya.	Do. . .	P. L. .	5·80	6th May 1927	Do.
Do. .	(684) Mr. A. Sundararami Reddi.	Do. . .	M. L. .	44·30	28th July 1927.	30 years.
Do. .	(685) Mr. P. Chenga Reddi.	Garnet . .	P. L. .	54·79	13th December 1926.	1 year.
Do. .	(686) Mr. P. Gunnayya	Mica . .	P. L. .	4·40	16th March 1927.	Do.
Do. .	(687) Mr. M. Dasaratharami Reddi.	Do. . .	M. L. .	56·35	19th February 1927.	30 years.
Do. .	(688) Mr. P. Gunnayya Chetti.	Do. . .	M. L. .	14·51	14th July 1927.	Do.
Do. .	(689) Mr. P. Venkata-Subba Reddi.	Do. . .	P. L. .	56·75	25th March 1927.	1 year.
Do. .	(690) Mr. G. Chenchusubba Reddi.	Do. . .	P. L. .	12·61	30th September 1927.	Do.
Do. .	(691) Mr. Chunder Ramiah Chetti.	Do. . .	P. L. .	27·75	27th May 1927.	Do.
Do. .	(692) Mr. A. Narasingham.	Do. . .	P. L. .	1·27	18th November 1927.	Do.
Do. .	(693) Mr. P. Lakshminarasa Reddi.	Do. . .	M. L. .	3·43	19th October 1927.	30 years.
Do. .	(694) Ahamad Nawaz Zang Bahadur.	Do. . .	M. L. .	25·49	26th August 1927.	Do.
Do. .	(695) Mr. K. Kadandarami Reddi.	Do. . .	P. L. .	29·56	16th September 1927.	1 year.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore .	(696) Mr. K. Linga Reddi.	Mica . . .	P. L. .	3·66	20th July 1927.	1 year.
Do. .	(697) Mr. I. Ramasubba Reddi.	Do. . .	P. L. .	4·15	10th September 1927.	Do.
Do. .	(698) Mr. G. Chenchayya.	Do. . .	P. L. .	1·45	27th September 1927.	Do.
Do. .	(699) Mr. P. Venkayya	Do. . .	P. L. .	66·34	25th August 1927.	Do.
Do. .	(700) Do.	Do. . .	P. L. .	78·10	Do. .	Do.
Do. .	(701) Mr. K. Kodandram Reddi.	Do. . .	P. L. .	29·56	16th September 1927.	Do.
Salem .	(702) Mr. S. K. Ramachandar.	Magnesite and Chromite.	M. L. .	578·92	4th December 1927.	30 years.
Do. .	(703) Mr. R. Alagappa Mudaliyar.	Do. .	P. L. .	82·96	21st December 1927.	1 year.
Trichinopoly	(704) Middleton .	Phosphate nodules	P. L. .	430·22	11th May 1927.	Do.

NORTH-WEST FRONTIER PROVINCE.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bannu .	(705) Messrs. The Indo Burma Petroleum Company, Ltd.	Natural petroleum (including natural gas).	P. L. .	3040·0	August 1927	1 year.
Dera Ismail Khan.	(706) Do. .	Do. .	P. L. (Renewal)	6720·0	9th March 1927.	Do.
Do. .	(707) Do. .	Do. .	P. L. . (Renewal)	2995·2	10th September 1927.	Do.
Do. .	(708) Messrs. The Burma Oil Company, Ltd.	Do. .	P. L. .	4608·0	9th May 1927	Do.
Do. .	(709) Messrs. The Indo Burma Petroleum Company, Ltd.	Do. .	P. L. .	150	1st September 1927.	Do.
Do. .	(710) Messrs. The Burma Oil Company, Ltd.	Do. .	E. L. .	6 miles wide and 3 miles either side track from Doraban d to 3 miles beyond Moghalkot.	30th November 1927.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.* E. L.=*Exploring License.*

PUNJAB.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jhelum .	(711) L. Sant Ram Kapur, B.Sc.	Coal . . .	P. L. .	144·44	3rd September 1927.	1 year.
Mianwali .	(712) Messrs. The Attock Oil Company, Ltd.	Mineral Oil .	P. L. .	500·0	15th October 1927.	2 years.
Do. .	(713) The African Construction Corporation, Ltd.	Do. . .	P. L. .	3065·6	25th January 1927.	Do.
Shahpur and Attock.	(714) Do. .	Do. . .	P. L. .	3827·2 3168·0 659·2	3rd January 1927.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

SUMMARY.

Province.	Exploring License.	Prospecting License.	Mining Lease.	Total of each Province.
Ajmer-Merwara	..	21	2	23
Assam	..	14	1	15
Baluchistan	1	1	6	8
Bengal	..	1	..	1
Bihar and Orissa	..	5	16	21
Bombay	..	5	3	8
Burma	..	248	14	262
Central Provinces	..	261	50	311
Madras	..	38	17	55
N. W. F. Province	1	5	.	6
Punjab	.	4	..	4
Total of each kind and grand total, 1927 .	2	603	109	714
Total for 1926 .	1	616	(*a*) 141	758

(*a*) Includes four quarry leases.

Classification of Licenses and Leases.

TABLE 42.—*Prospecting Licenses and Mining Leases granted in Ajmer Merwara during the year 1927.*

DISTRICT.	1927.		
	No.	Area in acres.	Mineral.
	PROSPECTING LICENSES.		
Ajmer	14	45·4	Mica.
Do.	1	1·8	Mica and beryl.
Beawar	1	7·3	Graphite.
Do.	5	20·1	Mica.
TOTAL	21	..	
	MINING LEASES.		
Ajmer	2	Not stated.	Mica.

TABLE 43.—*Prospecting Licenses and Mining Lease granted in Assam during the year 1927.*

DISTRICT.	1927.		
	No.	Area in acres.	Mineral.
	PROSPECTING LICENSES.		
Cachar	2	6,035·2	Mineral oil.
Lakhimpur	5	18,581·0	Do.
Nowgong	3	4,608·0	Crude petroleum and its associated hydrocarbon.
Sadiya Frontier Tract	1	2,240·0	Mineral oil.
Sibsagar	2	7,840·0	Oil and coal.
Do.	1	3,488·0	Oil and its associated hydrocarbon.
TOTAL	14	..	
	MINING LEASE.		
Khasi and Jaintia Hills	1	1,920·0	Corundum and sillimanite.

TABLE 44.—*Exploring and Prospecting Licenses and Mining Leases granted in Baluchistan during the year 1927.*

DISTRICT.	1927.		
	No.	Area in acres.	Mineral.
	EXPLORING LICENSE.		
Sibi	1	261,120	Mineral oil.
	PROSPECTING LICENSE.		
Kalat	1	3,200	Mineral oil.
	MINING LEASES.		
Quetta Pishin	1	80	Coal and coal dust.
Zhob	5	50	Chromite.
TOTAL .	6	..	

TABLE 45.—*Prospecting License granted in Bengal during the year 1927.*

DISTRICT.	1927.		
	No.	Area in acres.	Mineral.
Chittagong Hill Tracts . .	1	4,313·6	Mineral oil.

TABLE 46.—*Prospecting Licenses and Mining Leases granted in Bihar and Orissa during the year 1927.*

DISTRICT.	1927.		
	No.	Area in acres.	Mineral.
	PROSPECTING LICENSES.		
Singhbhum	3	1,865·06	Manganese and iron ore.
Do.	2	1,228·65	Manganese.
TOTAL .	5	..	

TABLE 46.—*Prospecting Licenses and Mining Leases granted in Bihar and Orissa during 1927*—contd.

District.	1927. No.	Area in acres.	Minerals.
	MINING LEASES.		
Santal Parganas	13	43·24	Coal.
Singhbhum	1	296·00	Chromite.
Do.	1	133·24	Manganese.
Do.	1	82·20	Iron ore.
TOTAL	16	..	

TABLE 47.—*Prospecting Licenses and Mining Leases granted in the Bombay Presidency during the year 1927.*

District.	1927. No.	Area in acres.	Mineral.
	PROSPECTING LICENSES.		
Belgaum	2	2,698	Bauxite.
Kanara	3	2,370	Manganese.
TOTAL	5	..	
	MINING LEASES.		
Kanara	3	1,858·3	Manganese.

TABLE 48.—*Prospecting Licenses and Mining Leases granted in Burma during the year 1927.*

District.	1927. No.	Area in acres.	Mineral.
	PROSPECTING LICENSES.		
Akyab	8	26,806·8	Natural petroleum (including natural gas).
Amherst	11	12,870·4	All minerals except natural petroleum.

TABLE 48.—*Prospecting Licenses and Mining Leases granted in Burma during 1927*—contd.

District.	1927. No.	1927. Area in acres.	1927. Mineral.
	PROSPECTING LICENSES—*contd.*		
Amherst	3	18,560·0	Oil shale.
Do.	2	2,835·2	Antimony.
Lower Chindwin	10	30,259·2	Natural petroleum (including natural gas).
Magwe	5	5,510·4	Do.
Meiktila	1	345·6	All minerals and coal.
Mergui	63	34,553·6	Tin and allied minerals except mineral oil.
Do.	21	18,412·8	Tin.
Do.	19	22,604·0	All minerals except oil.
Do.	1	51,200·0	Tin and gold.
Do.	2	1,331·2	Tin and other minerals except oil.
Do.	2	691·2	Tin and all minerals except coal and mineral oil.
Minbu	2	908·8	Natural petroleum.
Myingyan	1	2,809·6	Do.
Northern Shan States	1	268·8	All minerals and precious stones.
Do.	2	313·6	Iron ore.
Pakokku	5	4,640·0	Natural petroleum.
Shwebo	2	10,553·6	Do.
Southern Shan States	16	25,862·8	All minerals except oil.
Do.	1	160·0	Coal.
Tavoy	43	32,160·0	Tin and wolfram.
Thaton	6	12,431·3	All minerals except oil.
Thayetmyo	12	29,181·4	Natural petroleum.
Toungoo	1	1,280·0	All minerals except natural petroleum.
Upper Chindwin	5	16,480·0	Natural petroleum including natural gas.
Do.	3	2,048·0	Coal.
TOTAL	248	..	
	MINING LEASES.		
Amherst	1	1,008·0	Tin ore.
Mergui	4	3,200·0	Do.
Do.	1	1,075·2	All minerals except natural petroleum and natural gas.

TABLE 48.—*Prospecting Licenses and Mining Leases granted in Burma during 1927*—contd.

DISTRICT.	1927.		
	No.	Area in acres.	Mineral.
	MINING LEASES—*contd.*		
Minbu	1	640·0	Natural petroleum (including natural gas.
Northern Shan States	1	172·8	Iron ore.
Tavoy	4	1,683·2	Tin and wolfram.
Do.	2	678·4	Tin, wolfram and allied minerals.
TOTAL	14	..	

TABLE 49.—*Prospecting Licenses and Mining Leases granted in the Central Provinces during the year 1927.*

DISTRICT.	1927.		
	No.	Area in acres.	Mineral.
	PROSPECTING LICENSES.		
Balaghat	75	8,989	Manganese.
Betul	1	634	Limestone.
Bhandara	29	2,968	Manganese.
Bilaspur	1	200	Do.
Do.	1	11,900	Coal and iron.
Do.	4	20,794	Coal.
Chhindwara	23	3,861	Manganese.
Do.	7	2,662	Coal.
Do.	1	101	Mica.
Drug	1	132	Galena.
Jubbulpore	2	363	Manganese.
Do.	5	404	Bauxite.
Nagpur	111	13,252	Manganese.
TOTAL	261	..	
	MINING LEASES.		
Balaghat	19	769	Manganese.
Bhandara	7	139	Do.
Drug	1	14	Galena.
Jubbulpore	2	54	Manganese.
Nagpur	21	1,521	Do.
TOTAL	50	..	

TABLE 50.—*Prospecting Licenses and Mining Leases granted in Madras during the year 1927.*

District.	1927. No.	1927. Area in acres.	1927. Mineral.
	PROSPECTING LICENSES.		
Bellary	2	925·41	Manganese.
Cuddapah	2	914·59	Asbestos.
Do.	1	62·08	Barytes.
Kurnool	8	145·84	Do.
Nellore	22	897·47	Mica.
Do.	1	54·79	Garnet.
Salem	1	82·96	Magnesite and chromite.
Trichinopoly	1	430·22	Phosphatic nodules.
TOTAL	38	..	
	MINING LEASES.		
Bellary	1	1,503·16	Manganese.
Nellore	15	820·64	Mica.
Salem	1	578·92	Magnesite.
TOTAL	17	..	

TABLE 51.—*Prospecting and Exploring Licenses granted in the N.-W. F. Province during the year 1927.*

District.	1927. No.	1927. Area in acres.	1927. Mineral.
	PROSPECTING LICENSES.		
Bannu	1	3,040·0	Natural petroleum including natural gas.
Dera Ismail Khan	4	14,473·2	Do.
TOTAL	5	..	
	EXPLORING LICENSE.		
Dera Ismail Khan	1	Not stated.	Natural petroleum including natural gas.

TABLE 52.—*Prospecting Licenses granted in the Punjab during the year 1927.*

DISTRICT.	1927.		
	No.	Area in acres.	Mineral.
Jhelum	1	144·44	Coal.
Mianwali	2	3,565·60	Mineral oil.
Shahpur and Attock . .	1	7,654·40	Do.
TOTAL .	4	..	

NOTE ON COKING TESTS MADE WITH GONDWANA COALS. BY CYRIL S. FOX, D.SC., M.I.MIN. E., F.G.S., *Officiating Superintendent, Geological Survey of India.*

I.—Introductory Remarks.

THE subject of India's reserves of good quality coking coal was discussed two years ago by members of the Mining and Geological Institute of India.[1] An impression was created at these meetings by some of the most experienced mining engineers that the supplies of coking coal, capable of yielding coke of metallurgical quality, were strictly limited.[2] Also, that, of these available reserves, by far the larger proportion was located in seams 12 to 18[3] in the Jharia coal-

[1] *Trans. Min. Geol. Inst. India*, Vol. XX, 1925, pp. 118-133; 1926, pp. 331-422.

[2] *Op. cit.*, 1926, pp. 348-358, Mr. R. G. M. Bathgate of the East Indian Coal Company said :—" My own rough figures of the good coking coals of Jharia allowing for the known natural-coked areas give 1,100 million tons as the gross original virgin coking coal of the field. From available records it would appear that, roughly, 180 million tons of coal to date have been despatched from this field. Assuming three-fourths of this total to be first class coal, we have 135 million tons of good quality coal despatched. This figure of 135 million tons, however, is far from being the total amount of coal exploited to yield these despatches. Mr. Treharne Rees did not overstate the case when he put the working loss at 33⅓ per cent. but to this latter figure must be added others bringing up a still more formidable total. Boiler consumption amounts (in 1923) to 15 per cent. on the despatch figure, or, using Treharne Rees' figure for working losses, 10 per cent. on the gross coal. Coal for labour, theft, etc., will easily account for a further 7 per cent. on despatch figures or, say, 5 per cent. on gross. Collecting these percentages we get 33⅓ *plus* 10 *plus* 5=48⅓ per cent. But this is not all. Fires, collapses, coal locked up under railway lands, coal in barriers, etc., represent very considerable quantities of coal lost, and I consider I am placing my estimate low by saying that 50 per cent. of the coal exploited is lost in producing the coal available for despatch from collieries."

" To despatch 135 million tons of coal, therfore, means that 270 million tons have been exploited, and the total of 1,100 million tons originally is now reduced to 830 million tons. This figure of 830 million tons gross of good quality coking coal in the field will suffer all the losses calculated for the past, unless hydraulic stowing becomes the general vogue. The total amount available for despatch on present-day general practice is thus likely to be in the region of 50 per cent. of 830 million, *i.e.*, 415 million tons." Concluding he says :—" If, however, I am out 25 per cent. or even 50 per cent. in my estimate, such error would not detract from the grave seriousness of the situation."

[3] *Op. cit.*, 1926, p. 395; Dr. David Penman, Principal of the Indian School of Mines, Dhanbad, stated :—" With regard to coal of good coking quality, I find that there is a total of over 600 million tons available in 17, 15, 14A, and 14 seams down to a depth of, say, 800 feet. If 13 seam is added, the total exceeds 800 millions ; and if a portion of 12 seam and a portion of 18 seam (both of which yield good coking coal) are added, the total approximates to 1,000 million tons. This figure is not greatly in excess of Mr. Bathgate's estimate of 830 million."

field.[1] It was admitted that an excellent coking coal was being worked in the Karharbari seam in the Giridih coal-field, and that the newer coal in the seams of Upper Assam about Margherita produced valuable coke. It was, however, pointed out that the Giridih lump coal was ear-marked for steam-raising purposes on the State Railways and that the slack coal was made into coke for foundry purposes in the railway workshops. The Assam coal was considered to be too far away and generally too high in sulphur to be attractive to the metallurgists of Bengal and Bihar.

The coking coal seams in Jharia belong to the lower section or the Barakar stage of the Damuda series. The same coal-bearing horizons occur in the adjacent coal-fields of Raniganj to the east-south-east and Bokaro to the west of the Jharia field. It was known that soft coke[2] is made in both the above mentioned coal-fields, and it was conceded that with blends of Jharia or Giridih coal with Raniganj coal metallurgical coke could be made. These opinions regarding the coking quality of the coal in the Raniganj field appear to have been largely influenced by experiments conducted in 1919 by G. C. Lathbury and G. W. Marshall.

Details of these experiments were published and circulated officially. In consequence of its limited circulation I have thought fit to give this report in full (*see* below p. 296). My purpose is to show that Messrs. Lathbury and Marshall restricted their investigations to coals largely from the upper (or Raniganj) stage of the Raniganj coal-field. As these seams cannot be correlated with the coking coal seams of the Jharia and Bokaro coal-field the above experiments cannot be considered as complete. The idea of further tests was encouraged by Sir Edwin Hall Pascoe, Director of the Geological Survey of India. In order to complete the investigation I approached Mr. H. Lancaster, Superintendent in Charge of the State Railway Collieries at Giridih. He very kindly consented to allow Mr. G. W. Marshall, who was willing, to continue the experiments. Wagon samples of coals of the lower (or Barakar) stage were sent from the Raniganj, Bokaro and Karanpura coal-fields.

I am greatly indebted to Mr. C. S. Whitworth, Chief Mining Engineer to the Railway Board, for the generous supply, free of all charges, of upwards of 100 tons of wagon samples of the various

[1] Mr. R. R. Simpson, Chief Inspector of Mines in India, had previously estimated the reserves of good quality coking coal for this field at 1,174 million tons.

[2] Known as 'poora koela' and containing about 8 to 10 per cent. volatiles and 25 to 30 per cent. ash.

coals necessary for the tests. Mr. H. Lancaster kindly provided all the Giridih coal for mixing purposes, free of cost. Messrs. Anderson Wright, through Mr. J. H. Thomas, forwarded the wagon load of normal Dhori slack without charge. Mr. N. Brodie of the Government Test House, Alipur, generously undertook to make drop tests on the coke samples in order to arrive at a tolerably quantitative estimate of the relative merits of the coke. Without this assistance it is quite evident that these experiments could not have been made.

II.—Report on experiments carried out at Giridih by Messrs. G. C. Lathbury and G. W. Marshall in 1919 on certain Coals for Coke-making.

'At the request of Sir George Godfrey, Coal Controller, some experiments were carried out at Giridih to find out whether certain coals, which up to the present have been considered as non-coking, would coke when mixed with coal of good coking qualities—Giridih coal being of this latter class.

'It was decided at first to make some laboratory experiments before making actual tests in the ovens, and for this purpose the Mining Engineer to the Railway Board picked out 20 different representative varieties of coal from the Raneegunge coal-field of which the coking qualities were known to be doubtful, very poor or non-existent.

'Samples were received from the following collieries and the analysis of the coal is shown opposite each :—

Serial No.	Owner or Agent.	Colliery.	Seam.	Moisture.	Vol. Matter.	Fixed Carbon.	Ash.
1	Balmer Lawrie & Company.	Joyramdanga	Top or Baraboni	2·8	32·55	53·95	13·50
2	Ditto.	Ditto	Bottom	3·9	31·95	57·55	10·50
3	Bird & Company	Charanpore	Top	4·1	32·50	55·50	12·00
4	Ditto.	Ditto	Bottom	4·1	32·20	56·35	11·45
5	Martin & Company	Ghusick	Nega	4·5	33·25	51·90	14·85

Serial No.	Owner or Agents.	Colliery.	Seam.	Moisture.	Vol. Matter.	Fixed Carbon.	Ash.
6	Martin & Company	Ghusick . .	Ghusick . .	5·1	34·05	56·15	9·80
7	Balmer Lawrie & Company.	Victoria .	Ramnagar . .	1·8	29·30	62·50	8·20
8	Ditto .	Kenda . .	Kenda . .	5·5	33·15	52·95	13·90
9	N. C. Sircar .	Madhabpore .	Madhabpore .	6·0	35·25	53·35	11·40
10	N. M. Choudhury.	Jamehari . .	Jamehari . .	4·8	30·45	47·95	21·60
11	Andrew Yule & Company.	Sanctoria . .	Hatnal . .	2·6	31·75	53·95	14·30
12	Ditto .	Ditto .	Dishergarh . .	2·8	34·70	59·40	5·90
13	Ditto .	Ditto .	Sanctoria . .	2·6	32·55	55·25	12·20
14	Linton Molesworth	West Gunge. .	30 feet . .	1·8	29·25	59·90	10·85
15	Martin & Company	Ramnagar . .	Ramnagar (bottom)	1·6	28·55	59·15	12·30
16	N. C. Sircar .	Babisol . .	Babisol . .	7·8	33·35	52·35	14·30
17	S. Banerjee & Company.	Kajora . .	Kajora . .	5·8	34·55	52·40	13·05
18	Turnbull Bros. .	Damaguria . .	Salanpur A . .	1·4	22·10	62·10	15·80
19	P. K. Chatterjee .	East Nandi. .	Choukidanga .	4·6	30·60	51·30	18·10
20	Bird & Company .	Hat-Gorre . .	Raghunathbutty .	3·3	31·75	48·65	19·60

NOTE.—The volatile matter, fixed carbon and ash are reckoned on the dry sample after driving off the moisture.

'Of the above, the laboratory experiments showed that it was no use making further investigations with regard to Nos. 10, 17, 19 and 20 as these could under no circumstances be utilised for coking.

'Many experiments were made in the laboratory by mixing with different quantities of Giridih coal and, as a result, it was possible to divide the coals up into different classes according to the quantity of Giridih coal which it was thought would be necessary to mix with them to obtain a resultant coke.

'The following coals were picked out as representing the above classes and practical experiments made in the ovens, Giridih coal being mixed in the proportion shown.

	Per cent. of Giridih coal used in mixture.
	Per cent.
1. Messrs. Balmer Lawrie and Company's Joyramdanga colliery—Bottom seam	75
2. Messrs. Bird & Company's Charanpur colliery—Top seam	75
3. Messrs. Martin & Company's Ghusick colliery—Ghusick seam	50
4. Messrs. Andrew Yule & Company's Sanctoria colliery—Hatnol seam	25
5. Messrs. Andrew Yule & Company's Sanctoria colliery—Dishergarh seam	25
6. Messrs. Linton Molesworth & Company's West Gunge colliery—30 feet seam	*Nil.*
7. Messrs. Martin & Company's Ramnagar colliery—Ramnagar (bottom) seam	*Nil.*

'The ovens in which the experiments were made are Simon Carvés' vertical flue regenerative type bye-product ovens.

'The time taken over the coking was approximately 36 hours in each case.

'The results pretty well confirmed the conclusions arrived at by the laboratory experiments.

'Samples of the coke made are sent in boxes numbered as follows and in each case 2 samples are sent marked A and B.

'A represents the better portion taken from the hottest part of the oven. B represents the remainder.

'It will be seen in each case that the higher heat produces a better quality of coke.

No. 1 Box.—Messrs. Balmer Lawrie & Company's Joyramdanga colliery—Bottom seam :—

A 20 per cent. of the charge.
B 80 per cent. of the charge.

No. 2 Box.—Messrs. Bird & Company's Charanpur colliery—Top seam :—

A 40 per cent. of the charge.
B 60 per cent. of the charge.

No. 3 Box.—Messrs. Martin & Company's Ghusick colliery—Ghusick seam :—

A 10 per cent. of the charge.
B 90 per cent. of the charge.

No. 4 Box.—Messrs. Andrew Yule & Company's Sanctoria colliery—Hatnol seam :—

A 10 per cent. of the charge.
B 90 per cent. of the charge.

No. 5 Box.—Messrs. Andrew Yule & Company's Sanctoria colliery—Dishergarh seam :—

A 30 per cent. of the charge.
B 70 per cent. of the charge.

No. 6 Box.—Messrs. Linton Molesworth & Company's West Gunge colliery—30 feet seam :—

A 40 per cent. of the charge.
B 60 per cent. of the charge.

No. 7 Box.—Messrs. Martin & Company's Ramnagar colliery—Ramnagar (Bottom) seam :—

A 30 per cent. of the charge.
B 70 per cent. of the charge.

'As a result of our investigations we have come to the following conclusions :—

(1) Nos. 7, 14, and 15 are good coking coals, though the quality of coke produced from them is not quite equal to that of the coke made from Giridih coal.

(2) Nos. 11, 12, and 13, whilst being coking coals, do not produce a satisfactory coke. We are satisfied, however, that a good coke can be produced by a mixture of 50 per cent. with good coking coal.

This especially applies to No. 12 on account of the low percentage of ash in the coal—the result being a very much cleaner coke. The coke made with 25 per cent. Giridih coal and 75 per cent. Dishergarh coal only contained 14·6 per cent. of ash.

(3) The remainder are purely non-coking coals and, even when mixed with 75 per cent. of Giridih coal, do not produce a really 1st class coke as will be seen by an inspection of the samples.

'The object of the experiments was to find out whether, by mixing non-coking coals with coking ones, a good coke could be obtained and thus increase the quantity of coal available for coke making. The present sources of supplies of good coking coals are not by any means inexhaustible and if good results could have been obtained by mixing coals, then the outlook would have been much brighter.

'The results, however, were disappointing though one cannot go so far as to say that they were a failure.

'By mixing 25 per cent. of non-coking coal with 75 per cent. of good coking coal a coke was produced but very much inferior to the coke produced from the good coking coal by itself.

'Unless the supplies of coking coals are seen for certain to be running very short then we think that little is to be gained by adopting the policy of mixing—though it may come to this in the future.

'It would, we think, be a better policy to break up large coal (good coking quality) and use it for coke making instead of other purposes.

'The coke obtained by mixing is certainly inferior and to obtain it we sacrifice a large amount of really good coke. When the non-coking coals have a high percentage of ash then it is still more undesirable to resort to mixing as not only is the resultant coke of poor quality, but it has the disadvantage of being very high in ash in addition.

'When a non-coking coal of low ash is mixed with a good coking coal the resultant coke may not be really first class, but it has the advantage of being cleaner.'

III.—Report on Experiments carried out at Giridih by Messrs. H. Lancaster and G. W. Marshall in 1927 on Coking Coals other than Jharia.

'Further coking tests were carried out at Giridih, with the idea of ascertaining whether or not the Indian reserves of coking coal can be increased from sources outside the Jharia and Giridih coalfields.

'The plants in which the experiments were carried out consist of 50 Simon Carvés vertical-flued regenerative ovens, with the necessary plant for the recovery and treatment of the bye-products. The ovens are each 33 feet long, 8 feet high and 20 inches wide,

and hold 10 tons of coal, yielding approximately 8 tons of coke on carbonization.

'The small coal received for coking is discharged into an underground hopper, from the bottom of which it is fed by a revolving table on to a 24″ rubber belt, which carries it to the coal elevator.

'This elevator delivers it to the top of a ferro-concrete storage bunker, having a capacity of 1,200 tons, with housing on the top for disintegrators, which crush the coal to a fine powder.

'From the bottom of this bunker, the coal is dropped through sliding doors into an electrically-driven charging car, which travels along the top of the ovens, and is able to charge any of the ovens with its load.

'The coke is pushed out of the ovens by means of an electrically-driven ram which travels along the front of the battery.

'The gas, distilled off from the coal in the ovens, is drawn away through a 28″ gas main by means of rotary steam exhausters and is cooled by passing through a cylindrical air cooler, and a 'serpentine' water cooler. It is then passed through a tar-extracting machine, and afterwards through vertically driven mechanical 'scrubbers' where the ammonia is absorbed by means of a fine water spray.

'About 50 per cent. of the gas is then passed back to the ovens, which are heated by burning the gas in a system of vertical flues built between each oven. The surplus gas is burned in gas-fired boilers at the power station.

'As we could not arrange to put the test coals through the disintegrators, suppliers were asked to send only finely screened dust. Dhori complied best with these instructions, and the benefit of coking coal in a finely ground condition is easily noticeable in the sample of Dhori coke.

'Similarly, several of the other coke samples illustrate the bad effect on the coke of a percentage of 'unground' pieces in the coal.

'The tests were carried out at an average temperature of 900° C., giving a coking period of 32 hours, and the coal was not compressed.

'Fourteen separate tests were made as follows :—

1. Kargali.
2. Two parts Giridih with one part Dhemo Main (Dishergarh).
3. Victoria Colliery.
4. One part Giridih with one part Victoria.
5. Ramnagar.

6. Two parts Ramnagar with one part Dhemo Main.
7. One part Begunia with one part Kargali.
8. One part Begunia with one part Dhemo Main.
9. Three parts Dhemo Main with one part Damagurria.
10. Three parts Kargali with one part Argada (Karanpura).
11. Three parts Dhemo Main with one part Argada.
12. Three parts Giridih with one part Argada.
13. Dhori.
14. Giridih.

TABLE I.

The proximate analyses of the various coals used were as follows :—

	Moisture.	Vol. Matter.	Fixed Carbon.	Ash.
Kargali	1·40	24·85	60·55	13·20
Dhemo Main . . .	1·10	32·45	57·35	9·10
Victoria	·95	25·95	62·90	10·20
Ramnagar	1·20	26·00	59·65	13·15
Damagurria	1·45	20·80	56·60	21·15
Begunia	1·80	27·35	65·65	15·20
Argada	1·55	29·85	51·00	17·60
Dhori	2·10	23·95	61·70	12·25
Giridih	1·60	24·65	60·35	13·40

TABLE II.

'The proximate analyses of the coke produced in the tests were as follows :—

Serial No.	Vol. Matter.	Fixed Carbon.	Ash.	Remarks.
1	·45	82·05	17·50	Good coke. Nearly equal to Giridih.
2	·45	82·10	17·45	Fair coke. Not as good as No. 1.
3	·55	85·35	14·10	Only moderate coke.

TABLE II—*contd.*

Serial No.	Vol. Matter.	Fixed varbon.	Ash.	Remarks.
4	·40	82·65	16·95	About the average of Giridih and Victoria.
5	·40	81·50	18·10	Disappointing. Proportion of inferior coke high.
6	·45	82·75	16·80	Surprisingly good. Nearly Giridih standard.
7	·60	80·25	19·15	Nearly equal to Giridih.
8	·65	81·55	17·80	Not as good as No. 7.
9	·40	81·00	18·60	Similar to No. 8.
10	·60	79·95	19·45	'Kargali' quality spoiled.
11	·40	81·10	18·50	Almost worthless.
12	·55	79·95	19·50	Not good, but better than Nos. 10 and 11.
13	·40	83·35	16·25	Very good coke.
14	·45	80·35	19·20	

NOTE 1.—The samples were dried before analysis. In practice, they would contain between 2 per cent. and 5 per cent. moisture according to the degree of quenching.

2.—The results of the drop tests carried out at the Government Test House, Alipur, are not given in this paper as the physical tests show all the coke to be well above the standard adopted for metallurgical coke.

The Dhori coal produced an excellent coke and the Kargali coke was practically up to Giridih standard.

'The coals, however, received from Dhori and Kargali were much lower in ash content, than would have been expected, and were probably selected from a good part of the seam.

'The Argada coal proved to be a genuine 'non-coker' and from a coking point of view can be classed as hopeless.

'The Damagurria coal possesses only slight coking properties, and, being high in ash content, is unsuitable for coking purposes.

'The best 'mixing' test was No. 6, where 1 part Dishergarh mixed with 2 parts Ramnagar, produced a coke which was much superior to the coke produced from Ramnagar coal alone.

'The other tests confirmed the conclusions drawn from the experiments carried out at Giridih in 1919 (see page 296),

viz., that whilst these 'poor-coking' coals produce a serviceable coke, when mixed with good coking coal, the mechanical quality would not generally be acceptable to consumers, whilst the ordinary good supplies were available.

'There is always the possibility however, that certain 'mixtures' may produce a coke, in which the mechanical depreciation is more than counterbalanced for certain uses, by a gain in chemical composition: *e.g.*, mixing Dhemo Main coal produced a 'cleaner' (lower ash content) coke, and from the complete analyses of the samples of coke obtained in the above experiments, this possibility may be found to operate beneficially with regard to other constituents such as phosphorus and sulphur.

'The tests strikingly confirmed the knowledge that coals which produce poor coke at a carbonising temperature of say 850° C, may produce really good coke at say 1,100° C, and the present tendency of the coking industry to carbonise at higher temperatures, will undoubtedly bring into the category of 'coking coals,' many coals which have previously been considered to possess poor coking qualities.'

'It may thus be stated that the potential supplies of coking coal are now greater than was thought 10 years ago, though the extra coke produced will be more of the 'furnace' than the 'foundry' quality.'

IV.—Reserves of Coking Coal.

It is clear from the above experiments that coal capable of producing metallurgical coke is available in the Bokaro coal-field and in several of the upper seams of the Barakar stage and in the lower seams of the Raniganj stage in the western part of the Raniganj coal-field. The coals of the Karanpura coal-field cannot be considered as having been really tested. The lower section of the thick coal of Damagurria has decided coking properties, while the bottom seam (Laikdik) in Victoria colliery and the Ramnagar and Begunia seams (all in the Barakar stage of the Raniganj coal-field) were previously known to yield a tolerable coke and this has been confirmed. The Dishergarh seam (Raniganj stage) also yielded a very attractive though perhaps somewhat soft coke. It has been proved that a certain section of the thick coal at Kargali and Dhori in the Bokaro coal-field is capable of yielding a satisfactory coke. For purposes of experimental mixing I secured a typical non-coking coal from Argada

in the Karanpura coal-field. To keep a check on the behaviour of various blends it was agreed to use mixtures with Giridih coal (slack). I therefore recommended that the following charges should be used in the coke oven tests:—

(*a*) Ramnagar coal slack from Ramnagar colliery.
(*b*) Ramnagar with Dishergarh (Dhemo Main).
(*c*) Laikdih (Victoria colliery).
(*d*) Laikdih with Giridih.
(*e*) Begunia with Dishergarh.
(*f*) Begunia with Bokaro (Kargali).
(*g*) Dishergarh with Giridih.
(*h*) Dishergarh with Karanpura (Argada).
(*i*) Bokaro (Kargali).
(*j*) Bokaro (Kargali) with Karanpura (Argada).
(*k*) Bokaro (Dhori colliery).
(*l*) Giridih with Karanpura (Argada).
(*m*) Giridih.

In all these cases dust, or at all events slack coal, was used. In the case of Damagurria it must be recorded that the dust represented the whole seam, whereas it is known that the lower section of the seam is much superior to the rest of the coal. In my opinion a screened sample of the dust and slack from the Damagurria lower section is well worth a trial, both alone and mixed with Dishergarh. In the case of Kargali and Dhori, particularly the latter, the slack was obtained from the upper section of the seam; this is quite in order as this section of the seam is being separately worked. There is little doubt that the same seam should also be worked in sections in the State Railway collieries in the Bokaro field. It is, of course, known to be the custom in each of the iron-works that the coke is made from a blend of at least three and sometimes six and seven coals: *e.g.*, The Indian Iron and Steel Co. use coking coals from the following Jharia seams:—

No. of seam.	Colliery.
13, 14 and 15	Gaslitan.
12, 13, 14 and 15	Union.
12, 13, 14 and 15	Sendra. Standard. Khas Jharia. Bhulanbararee.
11	National.
11 and 12	Khas Angarpathra

The analysis of the coals (when mixed together) is :—

	Per cent.
Moisture	1·98
Volatile matter	25·74
Fixed carbon	62·20
Ash	11·58
Sulphur	0·50
Phosphorus	0·10

while a complete analysis of the coke produced is :—

	Per cent.
Moisture	2·58
Volatile matter	1·32
Fixed carbon	76·45
Ash	19·37
Details of ash—	
Silica	9·40
Alumina	5·59
Ferric oxide	2·44
Lime	0·89
Magnesia	0·12
Phosphoric oxide	0·41
Sulphur	0·52
	19·37

I have been unable to extract a definite specification of the suitability of a coke for metallurgical purposes, especially for blast furnace coke, from a competent authority or from any of the metallurgists at the Indian iron smelting centres. They naturally demand low-ash, moderately porous hard coke, but they accept and use material far below the quality they desire.

In a paper read before the West of Scotland Iron and Steel Institute (in 1925), Mr. Edgar C. Evans is credited with saying that "the problem has yet to be solved of devising a suitable test which would give both the coke maker and the blast furnace manager an idea as to the behaviour of coke in the furnace."

At my request Mr. H. Brodie, Superintendent-in-Charge of the Government Test House at Alipur very kindly tested samples of the coke made during the Lancaster-Marshall experiments. The test consisted in dropping 6 pieces of coke of each lot from a height of 5 feet on to a steel plate. It was arranged that if 25 per cent. of the

fragments passed through a 1-inch screen the coke should be considered useless for blast furnace purposes. In no case did small material from the drop tests amount to more than 2 or 3 per cent. So that according to this specification all the coke produced in the experiments is well above the standard required. I have therefore not considered it necessary to include Mr. Brodie's results in this paper. I think, however, that a ball mill testing machine would give a more satisfactory physical test. As regards ash percentage the greatest desideratum is uniformity. It is far more useful to have a steady 20 per cent. ash than it is to have fluctuations from 16 to 22 per cent. ash. The composition of the ash is important, but the uniformity of this composition is more important. The phosphorus percentage of Indian coals is receiving greater attention to-day than before. Detailed chemical analyses of coals from definite seams should be made by the various firms engaged from samples taken from *known* positions.

Recent analyses of Indian coals are given on the following pages.

TABLE III.—*Analyses of typical best Jharia coking coals.*

—	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Moisture	1·30	1·27	1·67	1·80	1·27	1·10	1·10	1·45	1·30	1·08	1·70	2·11	1·97	1·58
Volatile matter*	24·90	21·80	23·40	30·27	22·85	19·60	20·00	26·40	23·00	18·52	26·70	28·00	27·66	23·65
Fixed carbon *	64·70	68·96	68·00	59·18	64·70	65·70	66·60	64·45	66·10	68·18	62·30	60·20	59·90	62·15
Ash*	10·40	9·24	8·60	10·55	12·45	14·70	13·40	9·15	10·90	13·30	11·00	11·80	12·44	14·20
Calorific value (calories)	7,885	7,941	7,731	7,335	7,457	7,237	7,528	7,670	7,690	7.176	7,517	7,344	7,598	7,558

* Moisture free basis.

1. No. 14-A seam, Standard colliery (F. W. Heilgers & Co.) ; analysis by Alipur Test House.
2. No. 14-A seam, Lodna colliery (Turner Morrison & Co.); analysis by Alipur Test House.
3. No. 14-A seam, Bararee colliery (Jardine, Skinner & Co.); analysis by Alipur Test House.
4. No. 14 seam, Bhowra colliery (Mackinnon, Mackenzie & Co.); analysis by Alipur Test House.
5. No. 14 seam, Bhuggutdih colliery (Andrew Yule & Co.); analysis by Alipur Test House.
6. No. 14 seam. Gaslitan colliery (Octavius Steel & Co.); analysis by Alipur Test House.
7. No. 14 seam Loyabad colliery (Bird & Co.); analysis by Alipur Test House.
8. No. 15 seam, Bagdigi colliery (Villiers, Ltd.); analysis by Alipur Test House.
9. No. 15 seam, Bullihari colliery (Jardine, Skinner & Co.); analysis by Alipur Test House.
10. No. 15 seam, New Tethuriya colliery (Shaw, Wallace & Co.); analysis by Alipur Test House.
11. No. 17 seam, Jamadoba colliery (Tata Iron & Steel Co.); analysis by Alipur Test House.
12. No. 17 seam, Noonudih-Jitpur colliery (Bengal Iron Co.); analysis by Alipur Test House.
13. No. 17 seam. Kendwadih colliery (Macneill & Co.); analysis by Alipur Test House.
14. No. 17 seam, Behmandih colliery (H. V. Low & Co.); analysis by Alipur Test House.

TABLE IV.—*Analyses of typical fairly good Jharia coking coals.*

—	1	2	3	4	5	6	7	8	9	10	11	12
Moisture	1·46	0·70	1·10	1·00	1·00	1·10	0·90	0·75	1·30	1·30	1·40	1·80
Volatile matter*	14·00	18·75	23·57	20·50	20·70	22·45	20·10	23·00	24·50	25·20	28·05	28·80
Fixed carbon*	69·40	63·05	62·83	61·40	62·60	62·05	66·00	61·55	60·20	64·70	60·50	59·30
Ash*	16·60	18·20	13·60	18·10	16·70	15·50	13·90	14·55	15·30	10·10	11·45	11·90
Calorific value (calories)	7,299	6,882	7,576	7,142	6,874	7,245	7,200	7,211	7,240	7,572	7,437	7,209

*Moisture free basis.

1. No. 10 seam, Bastacolla colliery (Balmer, Lawrie & Co.); analyses by Alipur Test House.
2. No. 10 seam, Kustore colliery (Kilburn & Co.); analysis by Alipur Test House.
3. Nos. 10 and 11 seams, Bhowra colliery (Mackinnon, Mackenzie & Co.); analysis by Alipur Test House.
4. No. 11 seam, Ekra Khas colliery (Maharajah of Cossimbazar); analysis by Alipur Test House.
5. No. 11 seam, Kusunda Nyadee colliery (Martin & Co.): analysis by Alipur Test House.
6. No. 12 seam Bhuggutdih colliery (Andrew Yule & Co.); analysis by Alipur Test House.
7. No. 12 seam, Central Kirkend colliery (Anderson, Wright & Co.); analysis by Alipur Test House.
8. No. 13 seam, Kustore colliery (Kilburn & Co.); analysis by Alipur Test House.
9. No. 16 seam, Bhagaband colliery (F. W. Heilgers & Co.); analysis by Alipur Test House.
10. Nos. 16 and 17 seams, Pootkee colliery (Mackinnon, Mackenzie & Co.); analysis by Alipur Test House.
11. No. 18 seam, Jamadoba colliery (Tata Iron & Steel Co.); analysis by Alipur Test House
12. No. 18 seam, Noonudih-Jitpur colliery (Bengal Iron Co.); analysis by Alipur Test House.

TABLE V.—*Analyses of coking coals, Western portion of the Raniganj coal-field.*

—	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Moisture	1·35	2·55	2·25	1·48	2·15	2·81	2·10	2·90	2·00	1·52	1·20	1·40	1·40	1·30
Volatile matter*	32·75	34·05	32·80	30·60	31·05	32·00	27·60	27·00	25·30	27·85	25·40	27·40	26·00	22·40
Fixed carbon*	56·00	54·65	55·70	58·60	48·90	59·00	60 00	59·70	57·60	60·90	59·00	59·90	62·60	62·00
Ash*	11·25	11·30	11·50	10·80	10·05	9·00	12·40	13·30	17·10	11·25	15·60	12·70	11·40	15·60
Calorific value (calories)	7,300	7,169	7,194	7,504	6,346	7,469	7,194	7,271	6,737	7,387	7,170	7,215	7,632	7,223

*Moisture free basis.

1. Dishergarh seam, Parbelia colliery (Andrew Yule & Co.) ; analysis by Alipur Test House.
2. Dishergarh seam, Methani colliery (Macneill & Co.) ; analysis by Alipur Test House.
3. Dishergarh seam, Burra Dhemo colliery (Andrew Yule & Co.) ; analysis by Alipur Test House.
4. Dishergarh seam, Barmondia colliery (Balmer, Lawrie & Co.) analysis by Alipur Test House.
5. Hathnal seam, Sanctoria colliery (Andrew Yule & Co.) ; analysis by Alipur Test House.
6. Sanctoria seam, Seetalpur colliery (Andrew Yule & Co.); analysis by Alipur Test House.
7. Begunia seam, Begunia Khas colliery (Maharajah of Cossimbazar) ; analysis by Alipur Test House.
8. Ramnagar seam, Ramnagar colliery (Martin & Co.) ; analysis by Alipur Test House.
9. Borrea (3rd) seam, Borrea colliery (Balmer, Lawrie & Co.) ; analysis by Alipur Test House.
10. Victoria top seam, Victoria colliery (Balmer, Lawrie & Co.); analysis by Alipur Test House.
11. Victoria middle seam, Victoria colliery (Balmer, Lawrie & Co.) ; analysis by Alipur Test House.
12. Victoria (10′+17′) Bottom seam, Victoria colliery (Balmer, Lawrie & Co.) ; analysis by Alipur Test House.
13. Victoria lower (17′) Bottom seam, Victoria colliery (Balmer, Lawrie & Co.) ; analysis by Alipur Test House.
14. Victoria upper (10′) Bottom seam, Victoria colliery (Balmer, Lawrie & Co.); analysis by Alipur Test House.

TABLE VI.—*Analyses of Indian coals and coal ash.*

—	1	2	3	4	5	6		7
						Lower 24 ft.	Upper 30 ft.	
Moisture	1·50	1·50	1·3	2·0	2·25	1·36	1·91	2·50
Volatile matter	25·10	22·82	27·4	27·4	34·11	31·07	31·19	30·25
Sulphur	0·39	0·24 Fixed 0·52 Volatile	?	..	0·39	0·91	0·65	0·36
Fixed carbon	58·33	64·68	57·3	55·20	53·64	52·81	51·33	51·25
Ash—Total	14·68	11·00	14·00	15·40	10·00	14·76	15·35	16·000
Ash details—								
Silica	9·689	4·914	7·072	8·285	5·050	8·66	8·56	7·760
Alumina	3·523	3·939	4·029	3·953	2·400	4·62	5·37	5·612
Ferric oxide	0·616	0·565	1·159	1·760	1·000	1·26	1·04	1·233
Manganese oxide	0·135	?	0·022	0·057	?	..	..	0·305
Lime	0·188	0·816	0·70	0·508	1·000	0·15	0·31	0·240
Magnesia	0·132	0·371	0·141	0·215	0·250	0·02	0·06	0·128
Sulphur trioxide	0·023	?	?	?	?	0·02	0·01	?
Phosphorus pentoxide	(ash) 0·179	0·185	0·508	0·252	0·314	(ash) 0·12	(ash) 0·21	0·083
Other constituents	0·187	?	0·477	0·367	?	..	..	0·789
Phosphorus in coal	0·075	0·077	0·213	0·105	0·13	0·05	0·09	0·035

1. Giridih, Serampur colliery, Lower Karharbari seam; probable fair average near Dip Pit. (A. Dawes Robinson.)
2. Jharia, Bararee, machine-cut slack coal from lower part of No. 15 seam. (B. Wilson Haigh.)
3. Jharia, Jamadoba, mixed sample upper (7 ft. 6 in.) and lower (5 ft.) No. 18 seam, and 7 ft. of No. 17 seam; 0·434 per cent. TiO_2. (F. G. Percival.)
4. Raniganj, Ramnagar colliery, Ramnagar seam. This coal provided coke to the Bengal Iron Co. at Kulti. (A. Dawes Robinson.)
5. Raniganj, Saltore colliery, Dishergarh seam. (Ash averaged from two analyses of Dishergarh seam.)
6. Karanpura, Upper Sirka Argada Thick seam (60 feet). This coal cokes very well with Saltore coal (Dishergarh seam).
7. Rampur, Ib Riber, Sambalpur district. Moisture variable and often large. Contains 0·761 per cent. TiO_2. (F. G. Percival.)

Summing up the situation as we know it at present, it is possible to say that the Indian reserves of coking coal of good quality which can be used, either alone or by very careful mixing, for the preparation of coke of metallurgical quality, are briefly as follows :—

TABLE VII.

Quality.	Field and seams.	Amount in millions of tons (approx.).	Remarks.
I. Highest grade metallurgical coke.	Giridih, Lower Karharbari.	9	Specially low in phosphorus and ash. Suitable for making iron of Bessemer quality or ferro-manganese of standard grade. All allowances made.
	TOTAL .	9	
II. Good metallurgical coke.	Jharia, 13, 14A, 14, 15 and 17.	732	Good quality coal. Total estimated 1,100 million tons. Allowance 33⅓ per cent. Best coke from coal slack.
	Giridih, Lower Karharbari.	30	Excellent coke physically ; sometimes rather high in ash, particularly if made from coal slack.
	Raniganj, Victoria. Laikdih and Ramnagar.	50	This coke has been utilized in the Kulti furnaces. All allowances made ; 25 million tons each.
	TOTAL .	812	
III. Fair metallurgical coke.	Jharia, 10, 11, 12, 16 and 18.	800	Some of this coal is as good as Class II. Total estimated 1,200 million tons. Allowance 33⅓ per cent.
	Raniganj—		
	Dishergarh .	48	Best used by carefully mixing with 17 seam or others by experiment. All allowances made.
	Sanctoria . .	36	
	Begunia . .	25	
	Bokaro, Kargali .	365	Some of this is known to be of good quality Class II, but there is a little uncertainty about the ash in the remainder. All allowances made.
	TOTAL .	1,274	
IV. Good coking coal, but not of metallurgical quality.	Assam fields .	600	Very high in sulphur. If this impurity can be removed, this could be included in Class I or Class II.
	TOTAL .	600	

In regard to the allowance of $33\frac{1}{3}$ per cent. which I have made for losses in working, when calculating the reserves in Table VII, it is necessary to say that this figure has been adopted for the sake of convenience. From my personal knowledge of the Raniganj and Jharia coal-fields during the past three field seasons I can say definitely that in some cases even the high losses stated by Mr. Bathgate have been exceeded, but in other instances, the losses are very much less than $33\frac{1}{3}$ per cent. In a few cases the losses are almost negligible. Taken for definite areas under lease by colliery companies, where the coal of a given seam has been considered as worked-out or entirely unrecoverable at normal market prices, the figure of $33\frac{1}{3}$ per cent. is probably a tolerable average with the methods of mining and marketing in vogue at present. It is a little unfortunate that the term coal research in India is invariably taken as implying experimental work on the preparation of coal for the market or in respect of the efficient use of coal by consumers. There is as big a field for coal research in the examination of the methods of mining now in use and also in the mode of effecting coal sales.

From my own experience the greatest benefit to the coal industry would be the fixing of standard minimum prices for certain kinds of coal. After security of a fair sale price for the coal is obtained attention can be focussed on the still more important subject of economy in working. The compulsory adoption of sand-stowage for all seams of the quality for which market prices have been fixed is essential. Seams which are known to have been on fire must be worked on some system of sand-stowing. Collieries working seams which dip appreciably, and which have been worked on the pillar and stall system are known to have suffered almost total loss in the de-pillaring process. This shows that there is considerable room for improvement in the existing methods of working. Until the subject of efficient methods of extraction are clearly arrived at and adopted for the various, perhaps exceptional circumstances, which arise in the working of Indian coal seams, it is quite useless to allow any percentage for losses in working. It is far more satisfactory to state the *available* reserves—the total which *should* be extracted under perfect methods of working. The amounts of coal destroyed by igneous intrusions, or locked up under railway lands, valuable buildings, or as barriers between properties can be estimated almost exactly. In general the total under these heads is not large. It is when a seam comes to be worked and worked, under very trying market conditions, at a profit

that the losses cannot always be estimated. A single fire has led to the loss of a colliery and involved the coal of adjacent collieries when hopes had previously been entertained of a large profitable extraction. Coal research under the heads of "preparation for the market" and "efficiency in consumption" will lead to economies which should make a given weight of coal give greater heating value and thus save fuel and so give a longer life to the reserves. These factors of economy would not be of very much use to the coal industry in India at the present moment when higher prices and larger outputs seem to offer the only immediate solution to the depressed condition of the trade.

On the basis of the projected requirements of the Indian Iron and Steel Industry for 1928, *i.e.*, about 4 million tons of coking coal to give $2\frac{1}{2}$ million tons of coke, there is enough coal of Classes I and II to last more than 200 years if used exclusively for iron smelting. On the basis of the production of pig iron in Great Britain under normal conditions, *i.e.*, about 6 million tons of pig iron, the requirements of coking coal will be roughly 9 million tons a year, and the calculated reserves of Classes I and II would therefore last 70 years if exclusively utilized for iron smelting. If the reserves in Class III are included, the reserves of coking coal will last 500 years on the 1928 basis, and 200 years on the British basis.

It is ridiculous to imagine that these coals will be exclusively used for the production of metallurgical coke, but with such large margins there is scope for adjustment. There is time for a gradual re-arrangement in the use of coal for various purposes. By so doing, reasonable economies could be effected, whereby the better grades of coking coal may be conserved.

A ZINCH SPINEL, FROM SOUTHERN INDIA. BY W. A. K. CHRISTIE, B.SC., PH.D., M.INST.M.M., *Chemist, Geological Survey of India,* AND A. L. COULSON, M.SC., D.I.C., F.G.S., *Assistant Superintendent, Geological Survey of India.*

THE specimen[1] described below, sent by Messrs. P. Chenga Reddi and Company, Nellore, was found at Tummalatalupur (14° 17′ 30″: 79° 42′), near Jogipalli Shrotriem, Nellore district, Madras Presidency.

At one corner of the specimen there are indications of what may be crystal faces and on a part of the fractured surface there are definite, although distorted, striations. There seems to be no simple relationship between the orientation of these and of the problematical crystal faces.

Cleavage is not well developed in the specimen; in thin section it is seen to be octahedral, with four sets of cleavage lines. The mineral has a conchoidal to uneven fracture. It is brittle, with a hardness of 8. Its specific gravity is 4·55. Its lusture is vitreous, shining. The colour of the specimen is greenish black (Ridgway[2] XIX 37′n to XVIII 35′n). By transmitted light in a section 0·03 m.m. thick it is "dull opaline green" (Ridgway XIX 37′f.). At this thickness the mineral is semitransparent; ordinarily it is opaque. Its refractive index for sodium light is $1{\cdot}802 \pm {\cdot}002$ (immersion method with stannic and antimonious iodides in methylene iodide, the index of the liquid being determined in a hollow prism on a goniometer).

One corner of the specimen is encrusted with muscovite and plates of muscovite form frequent inclusions.

[1] Registered number M.-945.

[2] R. Ridgway, Colour Standards and Colour Nomenclature, Washington, 1912.

Carefully picked material has the following composition (W. A. K. Christie) :—

SiO_2	0·12	per cent.
ZnO	38·90	"
MnO	0·52	"
FeO	4·67	"
Al_2O_3	54·66	"
Fe_2O_3	0·81	"
H_2O (below 108°C.)	0·02	"
H_2O (above 108°C)	0·11	"
	99·81	

No other "heavy metals" were found; calcium and magnesium were absent; alkalines were not looked for. The state of oxidation of the manganese is unknown.

The mineral was decomposed by prolonged fusion with twenty times its weight of potassium pyrosulphate. After separation of the silica and elimination of platinum, zinc was precipitated as sulphide in dilute sulphuric acid solution by the method of F. G. Breyer,[1] converted to chloride and titrated with a solution of potassium ferrocyanide. Aluminium, iron and manganese were then precipitated three times with ammonia and hydrogen peroxide, and the oxides weighed together. Total iron and manganese were separately determined, the latter colorimetrically.

The mineral is attacked only with difficulty by a mixture of hydrofluoric and sulphuric acids; ferrous iron was therefore determined by Mitscherlich's method. The mineral was brought into solution by prolonged heating at 250°C. in a sealed tube (from which all air had been displaced by a current of carbon dioxide) with a mixture of one volume of sulphuric acid and one volume of water. Two determinations gave the same figure, 4·67 per cent.

Eliminating silica, water and manganese (which may be present as MnO or Mn_2O_3, or both of these), the percentages of the other constituents are :—

ZnO	39·27
FeO	4·72
Al_2O_3	55·19
Fe_2O_3	0·82
	100·00

[1] W. W. Scott, Standard Methods of Chemical Analysis, pp. 483 *et. seq.*, New York, 1917.

This gives a molecular ratio for (ZnO, FeO) : (Al_2O_3, Fe_2O_3) of 1 : 0·997, the theoretical spinel ratio being 1 : 1. If we suppose the manganese to be present in the ideal spinel form as MnO, Mn_2O_3 the recalculated percentages are :—

ZnO	39·06
FeO	4·69
MnO	0·17
Al_2O_3	54·88
Fe_2O_3	0·81
Mn_2O_3	0·39
	100·00

The molecular ratio of monoxides to sesquioxides is, of course, the same as before, 1 : 0·997. If all the manganese were present as monoxide, the ratio would be 1 : 0·983 ; if it were all sesquioxide, the ratio would be 1: 1·003.

The specimen has too much iron to be classed as automolite, too little iron and manganese for dysluite. It is normal gahnite, ZnO, Al_2O_3, with both radicles replaced to a small extent by iron oxides.

There appears to be only one other recorded occurrence[1] of zinc-spinel in India. C. S. Middlemiss found dysluite near Padiyur in the Coimbatore district of the Madras Presidency. It occurs in irregular masses in a felspar-rock containing corundum and sometimes biotite and muscovite. The felspar-rock occurs as veins in an elaeolite-syenite-gneiss.

[1] L. L. Fermor, *Mem., Geol. Surv. Ind.*, Vol. XXXVII, p. 37 (1909). *Cf.* also *Rec., Geol. Surv. Ind.*, Vol. XXX, p. 129, 1897. R. Beckenkamp in C. Hintze's "Handbuch der Mineralogie," Bd. 1, Abt. 4, p. 30, cites "R. R. Simpson, *Rec. Geol. Surv. Ind.*, 1910" in connexion with dysluite; this, however, is incorrect.

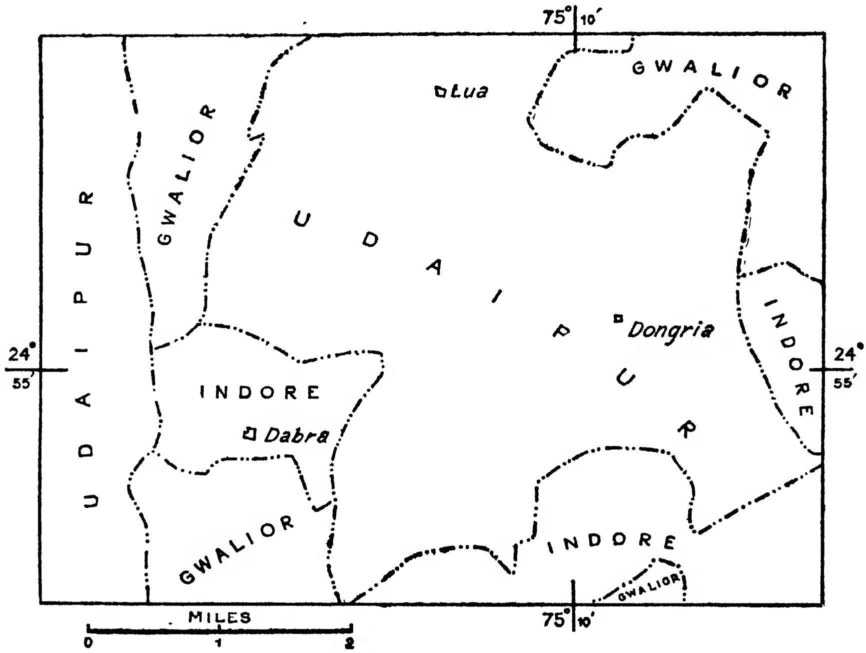
A NEW INDIAN METEORITE: THE LUA FALL. BY A. L. COULSON, M.SC. (MELB.), D.I.C. (LOND.), F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 21 to 25.)

Introductory.

MENTION of this fall has already been made in the Annual Reports of the Geological Survey of India for 1926 and 1927 (*Rec. Geol. Surv. Ind.*, LX, pt. 1, p. 13; *ibid.* LXI, pt. 1, p. 14). The meteoric shower fell on the afternoon of the 26th June, 1926.

Dabra.

Three fragments of a stone, numbered 292 A, 292 B and 292 C in the meteorite collection of the Geological Survey of India and of a total weight of 200·191 grammes, which fell at Dabra (locally known as Dabda; 24° 54′ 30″: 75° 7′ 30″) in the Nandwas *pargana* of Indore State, were presented to this department by the Prime Minister of Indore State. A fourth fragment with a weight of 124 grammes was deposited in the Holkar College Science Laboratory, Indore.



Sketch Map showing the positions of Dabra, Dongria and Lua.

One of two fragments of a stone which fell near Dongria (24° 55′ 30″ : 75° 10′ 30″) in Udaipur State was presented to this department by the Director, Department of Mines and Geology, Gwalior. This, numbered 292 D, weighed 53·3835 grammes when received. The other specimen, the weight of which was given as 116 grammes, has been retained in Gwalior. What is apparently another fragment of the same stone has been sent to Udaipur; the weight of this piece was $\frac{7}{16}$ of a tola (5·21 grammes).

Dongria.

Two stones, one weighing 8632 grammes and the other $9\frac{7}{16}$ tolas (110·08 grammes) fell upon the same day near Lua (24° 57′ : 75° 9′) in Udaipur State. These stones were sent to Udaipur but the larger one has since been received by this department on loan from the State authorities.

Lua.

Thus in all, four stones are known to have fallen, the total weight of fragments recovered from the respective localities of Dabra, Dongria and Lua being 324·19, 174·48 and 8742·08 grammes or 9240·75 grammes in all.

Total weight.

Particulars of the fall at Dabra are given in the following letter from the Prime Minister of Indore State to the Secretary to the Agent to the Governor-General in Central India :—

Circumstances of the fall at Dabra.

"*Subject;—Preservation of Aerolites.*

"I have the honour to state from the reports of the circle Sub-Inspector of Police, Nandwai, and the local Amin that on the 26th June, 1926, at 4-30 P. M. there was a great thunderstorm which lasted for about 7 minutes and at the same time a meteorite fell in the jungles of Dabda *pargana*, Nandwai. As the meteorite fell on a stone it went to pieces. The fall of the meteorite was witnessed by one Pitha Teli of the Dabda village who had been to the jungle for fetching firewood.

"2. Three pieces of a meteorite are sent herewith.

"3. It is also reported that a meteorite fell in Mouza Lua, Pargana Begu of the Udaipur State."

Enquiries made by this department elicited the following information from Pitha Teli given in a letter from the Prime Minister, Indore State, to the Secretary to the Agent to the Governor-General in Central India :—

"1. No light phenomena accompanied the fall; but there was a loud noise.

2. The meteorite fell towards the west.

3. Pitha Teli having been frightened, ran towards the village and came back after half an hour with some villagers, when the pieces picked up were found cold.

4. There was no characteristic smell in the neighbourhood.

5. As the meteorite fell on rocky ground, it went into pieces. Four pieces were recovered, three of which have been sent to you and the fourth deposited in the Holkar College Science Laboratory."

Circumstances of the fall at Dongria.

When Mr. G. H. Tipper of this department was in Gwalior and was shown two pieces of a meteorite, he suggested that one piece be sent to the Geological Survey of India. This was done and a collection of geological specimens was forwarded in exchange. It was first stated that the two pieces were picked up near Singoli (24° 58′ : 75°17′ 30″) on " one of the hills near Bengu (Mewar) " and that the time of fall was 4 P.M. on the 26th June, 1926. Later, however, the following letter was received from the Director, Department of Mines and Geology, Gwalior :—

" With reference to the falls of meteorites at Dabra and Lua mentioned in your departmental report for 1926, I beg to inform you that there appears to be a very close connection between these falls and the fragment of meteorite I sent to you with my letter No. 506, dated 15th January 1927. The fragments mentioned in my letter were actually picked up from a hill within the boundaries of the village Dongria (75° 14′; 24° 551, Map Sheet 236).

" The Thikanedar of Begu reports that there was a fall of one stone on the 26th June, 1926, near Lua, which weighed 9 $\frac{7}{16}$ tolas and that there occurred another fall at Dongria on the same day. He could get only a fragment from the latter locality which weighed $\frac{7}{16}$ of a tola. He sent both these stones to Udaipur.

" The above information together with the fall at Dabra mentioned by you, the closeness of the localities Dabra, Lua and Dongria and the date of the falls shows that the three falls were parts of a bigger one. The eye-witnesses say that there was a loud report like that of firing of a cannon and that the ' thunder-bolt' came from the south and dropped in the north-easterly direction.

" A comparison of the fragment sent by me with those you may have obtained from Dabra may prove the above supposition."

Circumstances of the fall at Lua.

The following letter was received from the Resident in Mewar, Rajputana :—

" With reference to your letter No. 3987/399, dated the 14th September, 1926, I have the honour to advise the despatch of a parcel by rail containing a fragment of the meteorite which is reported to have fallen in the village of Lua, Putta Begun, in the Mewar State, sometime between 3 and 3-30 P.M. on the 26th June, 1926, preceded by a loud atmospheric thunder."

Correlation of falls.

Lua is 3 miles N. N. E. of Dabra and Dongria is 3 miles E. N. E. of the same village. Falling upon the same day at localities within an area of a diameter of three miles, the connexion between the Dabra, Dongria and Lua falls is at once apparent. In addition, examination of

the specimens brings out the resemblance between the fragments. Accordingly the four fragments in the possession of this department have been given one number, 292, and the meteorite called after the village from which the largest fragment was recovered, *viz.*, Lua.

It will be noted that there is a considerable difference in the recorded times of fall. As watches are rare in country districts, this is not to be wondered at. The Dabra stone is said to have fallen at 4-30 P.M. and the Dongria stone at 4 P.M.; no time is given for the fall at Lua of the stone weighing 110·08 grammes, but it is stated that the larger stone, that weighing 8632 grammes, fell between 3 and 3-30 P.M.

Time of fall.

The three localities form almost an equilateral triangle and consequently it is impossible to work out the direction of fall as has been done by L. L. Fermor[1] in connexion with the Dokachi meteoric shower, notwithstanding the fact that the largest mass fell at the northern apex of the triangle. Pitha Teli (*supra.*, p. 319) has stated that the Dabra stone fell "towards the west." This might mean that it fell in the jungle west of the village or, alternatively, that its direction of fall was towards the west.

Direction of fall.

As this shower reached the earth between 3 P.M. and 4-30 P.M., *i.e.*, between the hours of noon and midnight, the meteorite from the disruption of which the several stones were formed, had direct motion,[2] *i.e.*, it must have been moving in the same direction as the earth in its orbit and thus reached the earth by overtaking it.

Motion of the meteorite.

When received, 292A weighed 155·042 grammes. Its longest axis is about 3¼ ches and it is obviously a fragment of a larger stone, its faces apart from the crust being fracture surfaces. A prominent crack traverses what is the bottom part of the specimen when held as depicted upon Plate 21 (figure 1); and it would require but little strain to break the specimen into two pieces. This incipient fracture probably occurred at the moment of impact on the rock as noticed by Pitha Teli. The front face is roughly parallel to the rear facebut whilst the crust is convex, the opposite fractured surface is appoximately plane.

General description of the meteoric fragments. No. 292 A.

[1] *Rec. Geol. Surv. Ind.*, XXXV, pt. 1, 1907, pp. 73, 74.
[2] "Meteorites," Farrington, Chicago, 1915, p. 43.

The crust is black, thin and very smooth and shows up in marked contrast to the grey of the fractured surfaces. Abundant small glistening faces of troilite, rust aggregates, rounded forms of nickel-iron resembling chondri and large white chondri, one of which has a diameter of 4mm. can be seen with the aid of a lens.

No. 292 B.

No. 292 B weighed 35·642 grammes when it was received by this department. It is shown upon Plate 21 (figure 4) and it again is definitely a fragment of a larger meteorite. It possesses but little crust and what little there is has been flaked away in its central portion. The specimen is roughly pyramidal in shape and though grey when first received, it has become rust-covered in the moist atmosphere of Calcutta. A definite chondritic structure and glistening faces of bronze-yellow troilite can be seen by the naked eye. This fragment is to be presented to the British Museum.

No. 292 C.

When received No. 292 C weighed 9·506 grammes and it is shown on Plate 21 (figure 5). Though also definitely part of a larger stone, it exhibits a moderate area of crust which is rusty-black in colour. This fragment was found to have a specific gravity of 3·534.

From ·113 grammes of this specimen, a thin section[1] was made, a photo-micrograph of which is shown on Plate 21 (figure 2). The section shows very well the chondritic structure of the meteorite, olivine forming numerous chondri which are chiefly polysomatic. Apart from the chondri and from nickel-iron and troilite, which occupy the spaces between the chondri, the only other mineral recognizable in the section is enstatite which forms an indistinct fibrous and eccentric chondrus and also occurs as a rectangular fibrous fragment (Plate 21, figure 2) entirely surrounded by troilite.

Fragments do not fit.

All attempts to join these three fragments were unsuccessful though they are apparently part of the same stone.

No. 292 D.

No. 292 D, the specimen from Dongria, depicted upon Plate 21 (figure 3) weighed 53·3835 grammes when received by the Geological Survey of India. There is an almost complete equatorial belt of thin, black crust encircling the fragment, which is undoubtedly part of a different stone from that which fell at Dabra. An examination of the specimen suggests that the fragment is the central part of a meteorite from which at

[1]Number 18054 in the register of microscope slides, Geological Survey of India.

least four other fragments have been detached either by the impact of landing or by human agency.

The crust is interesting in that it shows a few small pits where the nickel-iron has oxidised sufficiently to form with the silicates a relatively fusible compound; some rounded knobs can also be seen. The smooth crinkling of the crust is well shown in the photograph.

The specimen shows chondritic structure and with a lens iron-grey and tin-white nickel-iron and bronze-yellow troilite can be discerned. There is a purplish-red aggregation of material on the top edge of the specimen, microscopic examination of which indicated it to be composed of small crystals of olivine with rust aggregates. Of the five specimens examined, this alone possesses a marked bluish colour.

Large stone from Lua.

When received by this department, the large stone from Lua weighed 8632 grammes. It is a very fine specimen and is almost complete; an examination of its crustless areas suggests that a total of not more than about 200 grammes of the stone has been broken off either at the time of impact with the earth or subsequently by human agency.

The stone possesses two relatively plane surfaces which are roughly parallel to each other and whose distance apart averages about $3\frac{3}{4}$ inches. This parallelism is well shown on Plates 23 and 24 (figure 1 on both plates). When inspected in the position shown on Plate 22 (figure 1), the stone has the appearance of an arrow-head, the maximum width being $9\frac{1}{2}$ inches and height 6 inches; the base is concave.

The crust has the usual greyish-black colour and in places appears to be about 1mm. in thickness though it is generally less than this. On certain surfaces there appears to be a development of secondary crusts. Such flow lines as are found on the original crust are indefinite in direction and one cannot be sure of the position of the stone during its journey to the earth.[1]

A small surface of the crust of the fall shown in Plate II, figure 2, is seen in natural size on Plate 24 (figure 2); this shows the presence of small pits and knobs. Larger hollows in the surfaces can be observed (*see also* Plates 22 and 23). In Plate 22 (figure 1), two corrugated depressions may be seen on the surface of the meteorite on the right-hand side, one being fresh and caused by the impact

[1] *Rec., Geol. Surv. Ind.*, XXXLX, pt. 1, 1927, p. 146.

of the stone with the earth and the other showing similar corrugations but coated with crust.

A thin section (No. 18130) made from a small chip of this stone is very similar to the slide of the Dabra specimen, 292 C. Numerous polysomatic chondri of olivine are shown, the spaces between which are generally occupied by nickel-iron and troilite; some of the individual olivine crystals are relatively large. There are intergrowths of fibrous enstatite with olivine in some of the chondri (*see* Plate 25); but eccentric rayed masses of enstatite, which sometimes form separate chondri, can also be distinguished.

Classification.

Though no chemical analysis of any of the fragments has been made, it is proposed to classify the stones of this meteorite shower as follows:—Stone; No. 20, Grey Chondrite, Cg of Brezina.

EXPLANATION OF PLATES.

PLATE 21. FIGURE 1.—292A, Dabra, Indore State.

" " 2.—Photomicrograph of the Dabra meteorite from the Lua fall, No. 292C, showing a rectangular fibrous aggregate of enstatite and chondri of olivine.

" " 3.—292D, Dongria, Udaipur State.

" " 4.—292B, Dabra, Indore State.

" " 5.—292C, Dabra, Indore State.

" 22. FIGURES 1 and 2.—The Lua meteorite, Udaipur State (front and rear views).

" 23. " 1 and 2—The Lua meteorite, Udaipur State (end and bottom views).

" 24. FIGURE 1.—The Lua meteorite (end view).

" " 2.—Portion of the crust of the face of the Lua meteorite shown in Plate 22, figure 2 (natural size).

" 25. " 1.—Photomicrograph of the Lua meteorite, showing a fibrous aggregate of enstatite and chondri of olivine.

" " 2.—Photomicrograph of the Lua meteorite showing an idiomorphic crystal of olivine in a polysomatic chondrus of olivine and also other chondri of olivine.

MISCELLANEOUS NOTE.

Löllingite from the Hazaribagh District, Bihar and Orissa.

A mineral found in small amount in the Durria Mica Mine, situated in square Q 28 in the Kodarma Government Forest, and sent by Messrs. Tata Sons, Ltd., to this Department for examination and report has been identified as löllingite. There are not many previously recorded occurrences of the minerals of this group but leucopyrite has long been known to occur in the Hazaribagh district.[1]

The mineral, which is registered as M. 983 in the collections of the Geological Survey of India, has a density of 7·40. It contains abundant iron and arsenic, a little antimony and sulphur, but no cobalt or bismuth. Its high density indicates it to be the löllingite variety of the löllingite group.

Two small pieces of a mineral broken from a lump about the size of a football which had been found in one of Messrs. Tata Sons, Ltd.'s mica mines in square Q 28 in the Kodarma Government Forest, were forwarded by Mr. F. G. Percival of the Tata Iron and Steel Co., Ltd., and are interesting in this connexion in that they are varieties of löllingite.

One of these, M 980, has a density of 7·05 and contains abundant iron and arsenic with a little sulphur, antimony and bismuth, but no cobalt. The other, M 981, has a density of 6·55 and contains abundant iron and arsenic with a little sulphur and bismuth, but no antimony or cobalt.

In both instances the density was determined by means of the chemical balance, using polished fragments of the minerals; but even such polished material of the latter specimen contained a decomposition product in very thin veins. Pure material of M 981, were it possible to obtain it, might have a sufficiently high density (7·0)[2] to allow it to be classed with M 980 as leucopyrite.

The colour of all three specimens is steel-grey to silver-white and their streak is greyish black; their hardness is 5·5.

A. L. COULSON.

[1] Mallet, *Rec. Geol. Surv. Ind.*, VII, pt. 1, p. 43, 1874. Holland, *Mem. Geol. Surv. Ind.*, XXXIV, pt. 2, pp. 31, 51, 1902. Coulson, *Rec. Geol. Surv. Ind.*, LXI, pt. 2, p. 206, 1928.

[2] Dana, Mineralogy, p. 96.

MGIPC—M—VIII-4-10—20-9-28—800.

Fig. 1.—292 A DABRA.

Fig. 2—292 C DABRA, (Photomicrograph × 29)

Fig 3.—292 D. DONGRIA.

Fig 4—292 B. DABRA.

Fig 5.—292 C. DABRA.

K. F. Watkinson, Photos.

G. S. I. Calcutta

THE DABRA AND DONGRIA METEORITES FROM THE LUA FALL

(All about natural size.)

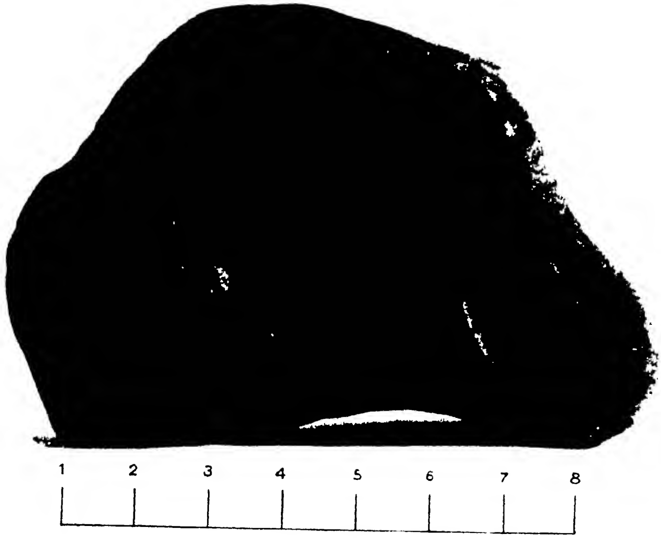


Fig 1. Front view (the scale is in inches).

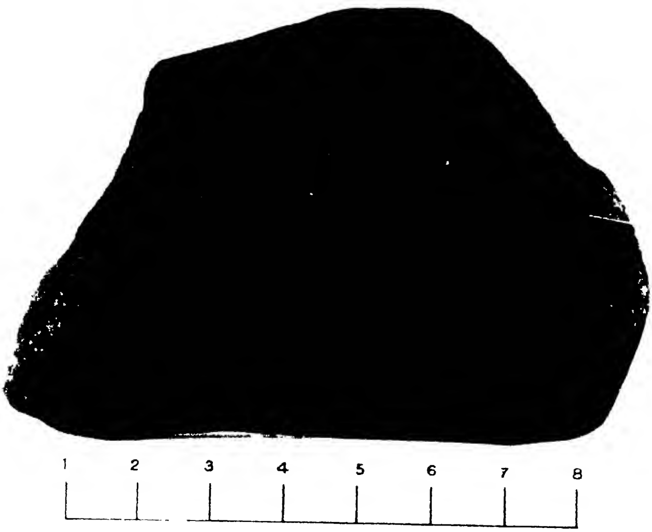


Fig. 2 Rear view (the scale is in inches).

K. F. Watkinson, Photos.

G. S. I. Calcutta.

THE LUA METEORITE.

Fig 1 End view (the scale is in inches)

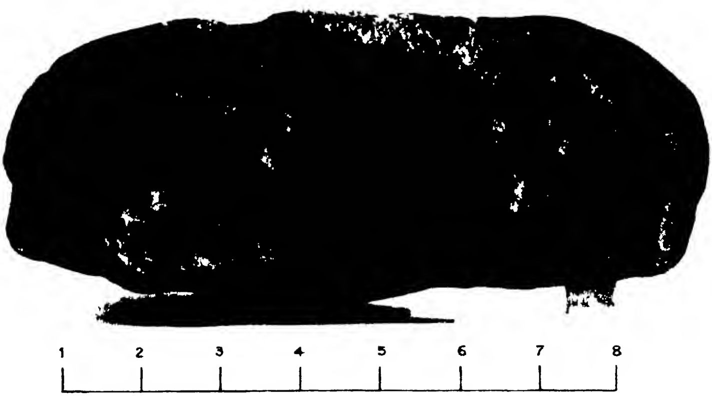


Fig. 2. Bottom view (the scale is in inches).

K. F. Watkinson, Photos *G. S. I. Calcutta.*

THE LUA METEORITE.

Fig 1 End view (the scale is in inches)

Fig 2 Portion of the Crust shown in Fig 2, plate 22, (natural size)

A. F Watkinson, Photos

G. S I. Calcutta

THE LUA METEORITE

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1929 [March

THE ERRATICS OF THE PUNJAB. BY G. DE P. COTTER, SC.D., F.G.S., *Superintendent, Geological Survey of India.* (With Plate 26).

Previous observers.

The erratic blocks of the North-West Punjab were alluded to, though vaguely, by Vicary as early as 1851 (1), and were subsequently described by Verchere (2), who supposed them to have been transported to their present position by icebergs floating on a lake. Between 1870 and 1881, A. B. Wynne and W. Theobald issued a number of papers dealing with the subject (3 to 11), which contain a great deal of information concerning the distribution of the erratics, but which, owing to the unfortunate habit of treating such questions in a highly controversial spirit, now form very dull reading.

The erratics, as may be gathered from the above papers, are found both to the north and south of the Kala Chitta range in Attock District, and, according to Theobald, they occur near Jhand railway junction south of the Kala Chitta, in lines running E.N.E.—W.S.W.

Wynne (6, p. 124), mentions one erratic of granitoid rock near "Kummerallia," that is Nurpur Karmalia in Sheet 43 C-5, A. 3 about 6½ miles W.N.W. of Campbellpur. This had a girth of 50 feet and a height of from 6 to 8 feet. Another large erratic close by was of basalt, and was 48½ feet in girth with a height of 12½ feet. Other erratics are described from near Hatti (Sheet 43 C-5, C. 2). At Jhand, the erratics comprise blocks of granite, syenite, gneiss,

hornblende-schist, and black slate. One, partially buried, measured 15 feet by 9¼ feet.

These erratics are associated with alluvium.

View of C. S. Middlemiss.

C. S. Middlemiss, writing in 1896 (12, pp. 45, 46) has some important remarks upon the subject of erratics, which may be quoted *in extenso*. He says—

'The only old moraine (indicating the agency of ice) that I have seen in the lower parts of Hazara occurs at a level of about 6,000 feet at Gool Maira, in the Koonhar valley. Doubtless many occur above this up the valleys leading down from Khagan, but I have not visited them.

'The subject of "erratics" in the Punjab provoked a little word-fencing between Mr. Wynne and Mr. Theobald about 15 years ago. Whilst Mr. Wynne named as erratic any displaced mass or boulder of foreign rocks whose means of transit appeared abnormal, Mr. Theobald confined the term to rocks in such positions as would entitle them *a priori* to a glacial origin, or at least to having been transported by ice in some form. In his paper on the occurrence of erratics in the Potwar, *i.e.*, the plain south of Hazara bordering the Indus and Sohan rivers up to the Salt Range, Mr. Theobald describes a number of huge blocks of crystalline granitoid gneiss, scattered about and imbedded in this silt mostly near Jhand; whilst others were described by Major Vicary between Hassan Abdal and Attock. Mr. Wynne has remarked on others in the bed of the Indus near Turbela and along the Sirun river (Hazara). Those on the Sirun and Indus rivers I shall show later on to be by no means displaced blocks, but to be actual outcrops (or quite close to actual outcrops) of the gneissose-granite of Hazara. As regards those of the Potwar, having never seen them, I am, perhaps, hardly entitled to an opinion ; so I will merely content myself by drawing attention to the fact insisted on by Theobald regarding the Jhand erratics that they occur in lines running E. N. E. and W. S. W. He interprets this as due to disposition by ice, but I would ask why, considering this is the normal strike of the country, they should not be similarly due to blocks weathered out nearly *in situ* from a ridge of crystalline rocks covered sparingly by, or protruding through, the Upper Tertiary sandstones ?

'As regards the erratics mentioned by Wynne south of the Salt Range, I think there can be no doubt that they were derived from the Salt-Range boulder-bed, whence they have simply subsided down hill.

'Having seen a good deal of glaciers and icework in the higher Himalaya, and having likewise worked over the Sub-Himalaya and Outer Himalaya through a large tract, I am bound to say that no reliable traces of glaciers at low levels (say below 5,000 or 6,000 feet) have ever come before my notice.

'I regret very much that I never saw the Potwar erratics (so called) and I would commend the study of them from the standpoint I have indicated to any future geologist who is in the neighbourhood.'

These remarks of Mr. Middlemiss have naturally cast grave doubt upon the theory of ice-transport to account for the erratics of the Potwar. Meanwhile the detailed geological mapping of the Potwar

has proceeded year by year, but no ridges of crystalline rocks have been found anywhere in the Potwar protruding through the Siwalik sandstones. The theory that the Jhand erratics are weathered rocks from a concealed crystalline ridge remains an unsupported hypothesis which it is difficult to accept.

Other occurrences of erratics.

In 1897, Sir H. H. (then Mr.) Hayden found large gneissic boulders in the Bára valley, in North Tirah at the foot of the western continuation of the Safed Koh (known as the Morga Range). He suggests that these may be erratics (13, p. 114).

Similar boulders were seen by myself at the debouchment of the *nala* at Lukman Khel village in the Safed Koh above Parachinar in 1926.

Mud-avalanches; their effects.

When such fleets of boulders are found in the talus fans of torrent-beds emerging from mountain ranges such as the Safed Koh, it is not necessary to postulate transport by ice. Mr. G. H. Tipper has described to me the effects of mudbursts in Chitral; these bursts are quite capable of transporting boulders of very great size. A graphic description of these mud-bursts, known locally in Baltistan as *shwas*, is given by Col. H. H. Godwin-Austin (14, p. 27). In describing a trip in the Mustakh Range, Baltistan, Kashmir, he says—

'Whilst lying in my tent, after finishing up my work, I heard an unusual rumbling sound, and on going out I found that all the men were wondering what it could be. After a few more seconds of suspense, some Balti coolies, who were cutting brushwood higher up the ravine, shouted out that the stream was coming down, and in a few seconds more we saw a black mass coming out of a lateral ravine from the right, and moving rapidly over the broad slope of boulders which formed the bed of the valley. Before the black stream reached us it divided into two, and we then saw that it consisted of a mass of stones and thick mud, about 30 yards in breadth and about 15 deep. The servants by the side of the little rill near the tents had just time to escape before it came down upon their fires. It was a most wonderful sight: a great moving mass of stones and rock, some of great size, measuring 10 feet by 6, all travelling along together like peas shot out of a bag, rumbling and tumbling one over the other, and causing the ground to shake. The large rocks lying in or near the edge of this moving mass would receive a few buffets, totter a little and finally roll in amongst the rest to carry others away in turn. No one who has not seen a flood of this kind, can form any idea of the mighty power of transport which the accumulated masses of water and melting snow acquire at these times, and I was almost bewildered by the spectacle. Our first alarm happened about six Shortly after another body of stones came down not so large as the first, but travelling much faster as it took the bed of the first and so met with fewer impediments.

These "shwas" are of frequent occurrence in the ravines particularly when the sides are of crumbling rock; they originate in landslips which stop the streams for a time and often assume such a size as to cause great injury to the cultivated tracts and villages below.'

Mr. D. W. Freshfield's suggestion.

There is an important paper by C. Rabot (15) on glacial reservoirs and their outbursts, to which a note (15, p. 547) has been added by Mr. Douglas Freshfield. Mr. Freshfield asks:—

'Is it not possible that a certain number of the more lowlying so-called "erratic blocks" may have been caught up by these floods and carried to their present positions ?'

Mr. and Mrs. Workman's description of *shwas*.

Mr. and Mrs. Workman in 1900 thus describe a *shwas* (16, p. 156)—

'We were selecting a place to pitch the tents when our attention was attracted by a peculiar rumble above. Far up the gorge, just below the glacier appeared a dark serpentine object, with high crested front coming towards us, following the windings of the stream. So rapidly did it advance, that there was barely time for the coolies to snatch up their loads, which fortunately had not been opened, and carry them fifty yards up the incline, before it was upon us. The dark slate coloured mass, some sixty or more feet wide and twenty to thirty high, presented a plastic appearance, and consisted of mud and stones of every size, some of them many tons in weight, which were rolled over one another, as if they were pebbles. This ponderous mixture of solid and semi-solid bodies moved with all the freedom and facility of a liquid, but with greater devastating power. A moment more, and its lofty front shot by with irresistable force and a crashing demoniacal roar. The rock-packed banks of the river crumbled into the rushing torrent, and large boulders toppled into and joined the mad procession, as if cohesion and gravity were bagatelles of the shadowy past. Rock masses ten to fifteen feet in diameter, lying in its course, were swept away to be seen no more. The terrific energy displayed by this cataract of rock was in a high degree awe-inspiring, and we were held spell-bound while it lasted.'

The same explorers, in a subsequent publication (17, p. 60), give a further account of the devastating effects of the *shwas* or mud avalanches, but the two quotations given above are sufficient. W. H. Twenhofel (18, p. 72) describes the mud-flow of Slumgullion in Colorado. The flow descended through a vertical distance of 2,600 feet down a slope of above 5 degrees, and over a length of $6\frac{3}{4}$ miles.

In the year 1841, a great flood occurred in the Indus. In early accounts it is said that this was caused by the bursting of a glacial dam in the Shyok tributary. A. Cunningham (18*a*, p. 99 sqq.) gives a graphic description, of which a few sentences may be quoted. He says—

"During December 1840 and January 1841, the Indus was observed to be unusually low between Torbela and Attock........... Early in June the barrier was burst,

and the collected waters of nearly six months rushed with overwhelming violence down the narrow valley of the Shayok, sweeping everything before them.......... The effect of the inundation at Torbela has been so graphically described by Major James Abbott from the lips of an eye-witness Ashraf Khan of Torbela, that I will quote it entire. ' At about 2 P.M. a murmuring sound was heard from the north-east among the mountains, which increased until it attracted universal attention, and we began to exclaim, What is this murmur? Is it the sound of cannon in the distance? Is Gandgurh bellowing? Is it thunder?' Suddenly some one cried out, 'The river's come.' And I looked and perceived that all the dry channels were already filled, and that the river was racing down furiously in an absolute wall of mud, for it had not at all the colour or appearance of water.''

On page 100 of the same book, Cunningham mentions that the flood, when passing Attock, was 30 feet high.

The notion that the great Indus flood of 1841 was caused by the bursting of a glacial dam in the Shyok is apparently incorrect, and has been denied by later writers. Dr. T. G. Longstaff (18*b*, page 648), who cites all the main authorities, points out that this flood was caused by a landslip which dammed the Indus near Gor, below Bunji.

Floods are also characteristic of Baluchistan. The reader may consult Sir T. H. Holdich's book entitled "The Indian Borderland," pages 14, 15.

Possible explanation of erratics of Attock District.

A possible explanation of the erratic blocks of the Attock district is transport by *shwas* or mud-avalanches. Some such explanation is necessary, since the arguments advanced by Mr. Middlemiss will not explain certain occurrences. Thus half a mile north-west of Bura, a village 4 miles east of Campbellpur, I saw two erratic blocks of gneissose granite (*minerals*—orthoclase, quartz, biotite abundant and muscovite less so) lying upon Triassic limestone. These blocks are shown in Plate 26. It is impossible in this case that the blocks could be derived from a concealed outcrop of gneiss hidden by an alluvial cap, since they rest upon Triassic limestone, and not on alluvium. There is also a large boulder of Hazara slate lying near by. The gneissose boulders are 9 feet high by 10 feet long by 6 feet wide, and 6 feet high by 7 feet long by 6 feet wide respectively.

About one mile south of Campbellpur there is a village named Jassian. East by south from this village there runs a range of hills known as the Rakh Kawa Gar. This consists of a main hill range, consisting of Trias, Giumals, and Nummulitic Limestone, and a minor ridge of Nummulitic Limestone to the north of it. The two ranges, the main one and the minor ridge to the north are separated

by a valley, in which here and there shales are exposed. But up to about three miles east by south from Jassian, the shale of the valley-bottom is covered by what looks exactly like moraine material. The deposit is a mixture of unsorted and miscellaneous material of all sizes, containing boulders of Giumal or Nummulitic limestone or of Attock slate or gneiss.

Again on the banks of the Haro river half-a-mile S. E. of Jassian, there is an erratic of brown quartzite, 4 feet high, 6½ feet long, 3½ feet broad. This is close to the Rakh Kawa Gar, and could not be derived from any concealed outcrop of quartzite. Mr. Middlemiss' explanation does not therefore apply to these particular erratics, while in the case of those erratics which rest upon alluvium, his view is unlikely to be correct, considering the results of the geological survey of the Attock district.

On the other hand, it must be admitted that there is no evidence of ice-action, such as scratched rock-surfaces, U-shaped valleys, etc.

But if we suppose these blocks to have been transported by the catastrophic action of mud-avalanches, many of our present difficulties will disappear. It may be noted that the Attock Slates are exactly the kind of formation which would break up under the action of frost and thaw into mud, and that the great extent of the Attock Slate and of the slate rocks of Hazara, described by Mr. Middlemiss (which, according to my results are to be correlated with the Attock Slates), would permit of the formation of mud-avalanches on a wide scale, provided the other necessary factors were present. In considering this question, we have to ask what changes have taken place in the Punjab within sub-Recent to Recent times.

Valley-plains of Baluchistan.

Among the most remarkable features of Baluchistan are the great valley-plains of the interior, and the deep gorges of the rivers draining those valleys, where they pass through the outer border range of hills. Thus the great Zhob valley, a broad open plain from Hindubagh eastward past Kila Saifulla to near Fort Sandeman, after passing the latter place becomes more and more shut in by the hills until it passes through a deep gorge through Waziristan to the plain south of Tank. So too, the Loralai and Thal Chotiali valley-plains are drained by the Beji and Nari rivers, which unite and pass through a deep gorge, before reaching the plain at Sibi. We

may compare also the valley-plains of the Dasht-i-Bedaulat and of Quetta with the gorges of the Bolan and the Harnai in the outer Baluchistan hills near Sibi. It is clear that uplifts along the ranges of the outer hills have dammed up the valleys causing the deposition of alluvium on a vast scale in the interior of Baluchistan, and leading to the formation of gorges where the rivers pass through the border ranges.

River rejuvenation in the Punjab.

The same phenomenon is seen in the Punjab. One of the clearest instances is the gorge of the Vahi river east of Mianwali in the Salt Range at Nammal, and the lake or marsh in the plateau inside the Range. The gorge of the Indus at Attock, though less pronounced, is another instance of this *rejuvenation* of the rivers and of the uplift within comparatively recent times of the outer ranges. Is it not possible that the erratics of Jhand may be due to some catastrophic outburst of mud and water through the Attock gorge due to the bursting of a temporary dam. It is assumed that the climate in sub-recent (glacial) times in the Northern Punjab was considerably colder than now, and throughout the Himalaya there is evidence that glaciers had a wider extension in the past than their present limits. In a period where glaciers were more widely extended, and in which earth movements tended to the damming back of the rivers, it seems possible that mud-avalanches on a far vaster scale than those of the present day may have carried the erratics and moraine material of the Attock district to their present position.

Source of erratics.

It may be asked whether we can say definitely from what part the erratic blocks were derived. In the present state of our knowledge, this is not possible. Gneissose granite is not found anywhere in the Attock district, and there seems very little doubt that the gneissose granite erratics come from Hazara, where this type of rock is found *in situ*. The rock composing the two erratic blocks at Bura (see above) most closely resembles specimen 9/498 collected by Mr. Middlemiss in North Hazara near Manserruh (Long. 73°, 14′; Lat. 34°, 18′). This rock is described by Mr. Middlemiss (12, p. 70). Nevertheless the resemblance is not such as to suggest identity, and the gneissose granite is sufficiently widely diffused over Hazara, to render it impossible to guess the source of the erratics except vaguely as coming from the hills to the north of Attock District.

Concluding remarks.

In the papers of Wynne and Theobald mentioned above, some weight is attached to the levels at which the erratic blocks are found in the present day. But, from what has been said regarding the rejuvenation of rivers and the formation of gorges, considerable changes of level have occurred within comparatively recent times. The Indus of to-day is no longer the Indobrahm, nor is the Soan more than a feeble relic of its former self. Following the work of Sir S. Burrard and Sir H. H. Hayden on the Himalaya and Tibet (19), Sir Edwin Pascoe (20, 21) has given us some idea of the history of these rivers. He considers that the Upper Jhelum " must have formed a continuous tributary with the Soan, and this river was no doubt responsible for the gravels and alluvial deposits of the present Soan valley, since these are rather more considerable than they would be, had they been entirely due to the modern Soan." (21, p. 464). Not only does the extent of the alluvium indicate a mightier river in the past, but the extreme coarseness of the gravels of the older alluvium would point to steeper gradients. It is not my intention in the present paper to enter into the difficult subject of Pleistocene drainage and changes in the courses of rivers. Those who wish to investigate this, should study Sir Edwin Pascoe's papers above quoted. But enough has been said to indicate that profound changes have taken place in this region of the Northern Punjab since Pleistocene times, and it does not seem impossible that at a former period natural forces were on sufficiently grand a scale to bring about such catastrophic glacial outbursts of water or of mud-avalanches as might have brought the erratic blocks of Attock District to their present position.

BIBLIOGRAPHY.

1. VICARY, MAJOR N . On the Geology of the Upper Punjab and Peshaur. *Quart. Journ. Geol. Soc.*, VII (1851), pp. 38-46.

2. VERCHERE, ALBERT M. Kashmir, The Western Himalaya and the Afghan Mountains. *Journ. A. S. B.*, XXXVI, part 2, pp. 9-50.

3. THEOBALD, W. . . On the Occurrence of Erratics in the Potwar. *Rec. Geol. Surv. Ind.*, X, pp. 43-45.

4. THEOBALD, W. . What is an Erratic? *Geol. Mag.*, V, pp. 333-334.

5. " . . On some Pleistocene deposits of the Northern Punjab. *Rec. Geol. Surv. Ind.*, XIII, pp. 221-243.

6. WYNNE, A. B. . . Note on the Tertiary zone and underlying rocks in the North-West Punjab. *Rec. Geol. Surv. Ind.*, X, pp. 107-132.

7. " . . On "Remarks etc." by Mr. Theobald upon Erratics in the Punjab. *Rec. Geol. Surv. Ind.*, XI, pp. 150-151.

8. " . . Notes on the Physical Geology of the Upper Punjab. *Quart. Journ. Geol. Soc.*, XXXIV, pp. 347-376.

9. " . . Travelled blocks of the Punjab. *Rec. Geol. Surv. Ind.*, XIV, pp. 153-154.

10. " . . On the Connexion between Travelled Blocks in the Upper Punjab and a supposed Glacial Period in Upper India. *Geol. Mag.*, VIII, pp. 97-99.

11. " . . What is an Erratic? *Geol. Mag.*, V, pp. 185-187.

12. MIDDLEMISS, C. S. . The Geology of Hazara and the Black Mountain. *Mem. Geol. Surv. Ind.*, XXVI.

13. HAYDEN, H. H., SIR . On the Geology of Tirah and the Bazar Valley. *Mem. Geol. Surv. Ind.*, XXVIII, Part I, pp. 96-117.

14. GODWIN-AUSTIN, H. H. On the Glaciers of the Mustakh Range. *Journ. Geol. Soc.*, XXXIV, pp. 19-56.

15. RABOT, C. . . Glacial Reservoirs and their Outbursts. *Geographical Journal*, XXV, pp. 534-548.

16. WORKMAN, MRS. F. B. AND MR. W. H. In the Ice World of the Himalaya. London, 1900.

17. Workman, Mrs. F. B. and Mr. W. H. Two Summers in the Ice-Wilds of Eastern Karakoram. London, 1917.

18. Twenhofel, W. H. . Treatise on Sedimentation. London, 1926.

18*a*. Cunningham, A. . Ladakh, Physical, Statistical, and Historical, with notices of the surrounding countries. London, 1854.

18*b*. Longstaff, T. G. . Glacier Exploration in the Eastern Karakoram. *Geographical Journal*, XXXV, p. 648.

19. Burrard, S. G. and Hayden, H. H. A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet. Calcutta, 1907-1908.

20. Pascoe, Sir E. H. . The Early History of the Indus, Brahmaputra and Ganges. *Quart. Journ. Geol. Soc.*, LXXV, pp. 138-157.

21. ,, ,, . Petroleum in the Punjab and North-West Frontier Province. *Mem. Geol. Surv. Ind.*, XL, Part 3.

THE CRETACEOUS DINOSAURS OF THE TRICHINOPOLY DISTRICT, AND THE ROCKS ASSOCIATED WITH THEM.

BY C. A. MATLEY, D.SC., F.G.S.

I.—INTRODUCTION.

Remains of Dinosaurs were discovered by H. F. Blanford in the Ariyalur Group of the Cretaceous rocks of the Trichinopoly district during the geological survey of that area in the years 1857-60.[1] A "bone-bed" was reported as being situated near Kallamedu (Cullmoad),[2] about six miles from Ariyalur, and numerous bones were seen by him in it, but were so friable and saturated by water that it was impossible to obtain any in an identifiable condition. The best specimen had somewhat the form of a scapula and measured 39 inches in length by 18 inches across at its broadest end. As he found a megalosaurian tooth in the deposit he came to the conclusion that the bones in the bed should also be assigned to *Megalosaurus*. The tooth was afterwards described and figured by Lydekker under the name of *Megalosaurus* sp.,[3] but I can find no further reference in geological literature to the scapula-like bone.

There is no record of any geologist having seen the bone-bed since Blanford's survey of this district. As the remains of dinosaurs are rare in India, and as it is only in this district that they occur in marine beds which contain cephalopoda and other zonal fossils that enable the geological horizon of the bones to be fixed with precision, it occurred to me that it would be worth while to explore this deposit during my visit to India in February 1925. The Director of the Geological Survey of India was sympathetic with my proposal and was good enough to depute one of his Sub-

---

[1] "On the Cretaceous and other Rocks of the South Arcot and Trichinopoly districts, Madras." *Mem. Geol. Surv. Ind.*, IV, pp. 139-140 (1865).

[2] There are many differences between the spelling of place names in Blanford's memoir and that in the latest *taluk* maps, which I used for my field work. In this paper the spelling in the recent *taluk* maps has been adopted and is followed in some cases by the insertion of the older spelling in parentheses.

[3] *Rec. Geol. Surv. Ind.*, X, p. 41 and *Pal. Indica*, Ser. IV, Pt. 3, pp. 26-27, Plate VI, figs. 6 and 7.

Assistants, Mr. P. N. Mukerjee, to accompany me. I wish to acknowledge the great help Mr. Mukerjee gave me in the field.

Our plan of work was to proceed from Trichinopoly by motor-bus service to a rest-house at Toramangalam, near Perambalur, which stands on the old gneisses, and from there to make a traverse across the lower beds of the Cretaceous succession until the higher beds were reached at Ariyalur. But, on learning that the motor-bus travelled twice daily, we determined to go by the morning service as far as Padalur, pay a hurried visit to the local base of the Cretaceous near Utatur, and complete the journey from Padalur to Perambalur in the afternoon. This little addition to the original plan resulted in the unexpected discovery of some reptilian remains near Neykkulam (Naicolum).

On arrival at Ariyalur, several days were spent in searching for and examining the Kallamedu bone-bed, after which we marched from Ariyalur to Utatur in order to make a further search for reptilian remains at Neykkulam before our return to Trichinopoly. Two traverses were therefore made, one in ascending and the other in descending sequence, across the greater part of the Cretaceous succession. A few remarks on the rocks and fossils will be made in the course of this paper.

II.—THE CRETACEOUS SUCCESSION.

The area occupied by the Cretaceous rocks of the Trichinopoly district is a classic region of Indian geology, and the survey by Blanford, during 1857 to 1860, with the description of the fossils by Stoliczka, was the most detailed piece of geological and palæontological work that had up to that time been undertaken in India. The strata range in age from Upper Albian to Danian, and it may be recalled that Blanford divided them into three groups, a lower or Utaṭur, a middle or Trichinopoly, and an upper or Ariyalur group. In passing, it may be remarked that the name for the middle group was not well chosen, as the Trichinopoly group is found nowhere near the city of Trichinopoly and it covers a smaller area in the Trichinopoly district than either of the other groups to which local village names have been given.

The rocks consist chiefly of sands and soft friable sandstones, with pebbly bands, among which are beds of clayey sand and clay (often gypseous), calcareous grits and shales, and seams of highly fossiliferous limestone. These strata lie on the Pre-Cambrian

gneisses and granites of the west and south; on the east they are overlain unconformably by the Cuddalore Sandstone, outliers of which are also found in the Cretaceous area. Each group of the Cretaceous transgresses the group or groups below, so that each group in turn rests in part on the basement gneisses. The rocks have a low dip, are little disturbed, form a flattish expanse of country, intersected by sandy *nalas* and are covered in places by regur and other superficial deposits.

I was able to see the nature of the deposits during the two marches between the base of the Cretaceous on the west and Ariyalur on the east, and to collect a few fossils. My fossil list includes the following species :—

I.—*Utatur Group.*

(*a*) 8¼ miles from Perambalur, on the Ariyalur road.
Lima ootatoorensis Stol.
Ostræa cf. *diluviana* Linne.
Exogyra sp. indet.

(*b*) Limestone, north of Odiyam (Odium) village.
Ptychoceras glaber (Whiteaves) Kossmat.
Lima interpunctata Stol.
Pinna intumescens Stol.
Trigonoarca gamana Forbes.
Exogyra haliotoidea Sow.
Turritella nodosa Roemer.

(*c*) Odiyam (Odium) village.
Eucalycoceras sp. (*newboldi* group).

(*d*) ¾-mile S. E. of Neykkulam (Naicolum).
Eucalycoceras ? sp. indet.
Acanthoceras sp. cf. *meridionale* Stol.
Turrilites costatus (Lam.) Stol.
Puzosia sp.
Trigonoarca cf. *abrupta* Forbes.
Phasianella incerta Forbes.

II.—*Trichinopoly Group.*

(*a*) Pilimisai (Pelamasey) village.
Scaphites similaris Stol.
Gyrodes pansus Stol.
Chemnitzia undosa Forbes.

III.—*Ariyalur Group.*

(*a*) 14¾ miles from Perambalur, at the bridge on the Ariyalur road, S.E. of Mattur.
'*Holcodiscus*' or '*Puzosia*,' new or malformed.
Trigonia semiculta Forbes.
Eriphyla lenticularis (Goldf.).
Pecten quinquecostatus (Sow.).
Alaria sp. indet.

(*b*) 17 miles from Perambalur, on the Ariyalur road, near Allinagaram.
Modiola typica Forbes.
Leptomaria indica Forbes (covered by *Ostræa*).

(*c*) North-west of Ariyalur.
Ostræa arrialoorensis Stol.
Ostræa vesicularis Lamk.
Plicatula instabilis Stol.
Pecten quinquecostatus Sow.
Anomia sp. indet.
Natica sp. indet.

(*d*) 1 mile W. of Ariyalur.
Hauericeras gardeni (Baily) Stol.
Hercoglossa.
Pecten curvatus Geinitz.
Plicatula instabilis Stol.
Ostræa vesicularis Lamk.

(*e*) 1½ miles from Ariyalur, on the Ottakovil road.
Cyrtoma nov. sp. cf. *planatum* (Forbes) (very abundant).

(*f*) 'Gryphæa' pisolitic limestone, S. of Ottakovil.
Ostræa vesicularis Lamk.
Exogyra ostracina Lamk.

(*g*) Near Ottakovil village.
Ostræa ungulata Schloth.
Radiolites sp. indet.

(*h*) ½-mile N. of Ottakovil.
Stigmatopygus elatus Stol. (very abundant) (=*Cyrtoma herschelianum* McClelland.

III.—THE KALLAMEDU BONE-BED.

The best way to reach the Kallamedu bone-bed from Ariyalur is to take the cart-road to Tamaraikkulam. Here the road forks and there is a choice of taking either the northern road to Ottakovil (Ootacoil) and striking eastwards across country for about 1½ miles, or of taking the eastern cart-track through Venkataramapuram to Kallamedu ("Cullmoad" of Blanford's memoir) from which village the *nala* should be followed northward. The ossiferous bed lies to the west of the *nala* in uncultivated and unenclosed country, and we experienced some difficulty in locating the deposit. Our first attempt resulted only in finding, in small stream-courses, a friable sandstone or sand-rock containing sandy concretions, many of them having a superficial resemblance to bones. Later, we found a few indubitable fragments of bone lying in the bed of the Kallamedu water-course, and by following them up into its eastern branch we at last discovered, on the plateau surface, a bone 36 inches long. More bones were found later in the same neighbourhood. The best indicator for a stranger who may wish to see the deposit is a bed of red clay, mentioned by Blanford (*op. cit.*, p. 139), the brightly-coloured escarpment of which makes a conspicuous feature in the landscape at a mile's distance. The bones should be looked for in the basal part of the sandy beds that lie on the clay.

The beds in which the bones are found are sands containing many sandy nodules and occasional seams of fibrous gypsum. The bones are not numerous, and are scattered. We found ten in all, seven of which were exposed within a radius of about fifty yards; the three others lay, well separated, about 100 to 150 yards away. All of them were found at the surface of the deposit and had been almost completely disinterred by denudation of the surrounding soft sands, so that each formed the crest of a little mound. The region in which they occur is arid, desert-like and shadeless, dissected by small *nalas* or stream-courses and bearing a sparse growth of low xerophytic scrub from which a few goats get what sustenance they can. Blanford appears to have discovered the bed during a monsoon period as he found the bones saturated with water, but at the time of our visit (February, 1925) the ground was very dry, as also were the bones. As was the case in Blanford's time the bones were in bad condition, sub-aerial agencies having played havoc with them. Saturation during the monsoons alternating with desiccation during the dry seasons, and expansion by day

under the intense heat of the unshaded tropical sun followed by contraction at night had split all the bones into fragments, and we found a talus of large and small pieces lying on the slopes around each bone. We spent much time in endeavouring to repair the bones sufficiently in the field to enable them to be conveyed to Calcutta, but our efforts were in vain as the lower surface of each bone was found to be as shattered and damaged as the exposed upper surface. For the following description I have therefore to rely on my field notes.

It is remarkable that all the bones found, ten in number, were limb or girdle-bones, and that not a single vertebra, rib, tooth, scute or other part of the skeleton was discovered. One important result of the examination was to show that these remains do not belong to a megalosaurian, as Blanford supposed, as their characters are quite distinct from those of the Theropoda. They are almost certainly sauropodous bones.

One of the bones was an upper limb-bone, probably a femur, possibly a humerus. Its proximal end and the greater part of the shaft had been badly damaged by exposure to the weather and a long train of fragments lay around it. Its distal end was still embedded, and excavation revealed the two condyles. The shaft was 12 inches across at its narrowest part. Its length as seen was 60 inches, and its full length was probably more. A rough sketch of this bone is given in figure 1. Another bone appeared to be the

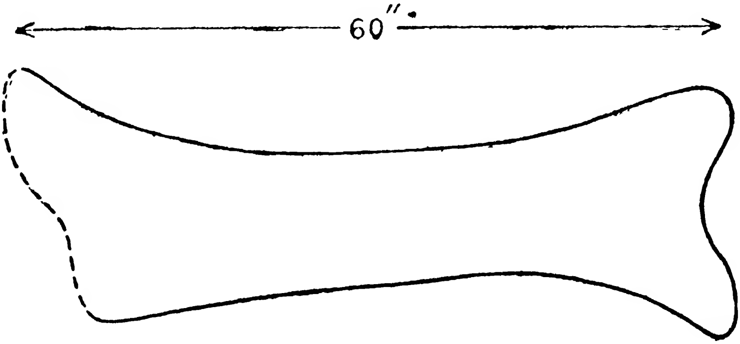


FIG. 1. Restored outline of large limb-bone (femur or humerus) from Kallamedu bone-bed.

proximal end of a great femur, of which the shaft and distal end had been completely destroyed. The part still left measured 23 inches long and 23 inches across. It could not be removed as it was cracked

into small fragments with their edges so corroded that the adjacent fragments did not fit. A third bone was probably part of a large sauropod scapula, but it was badly shattered and only a portion was preserved. One edge formed a concave curve 27 inches long; it was at least 18 inches wide, and had a thin flat expansion at the side opposite the curve.

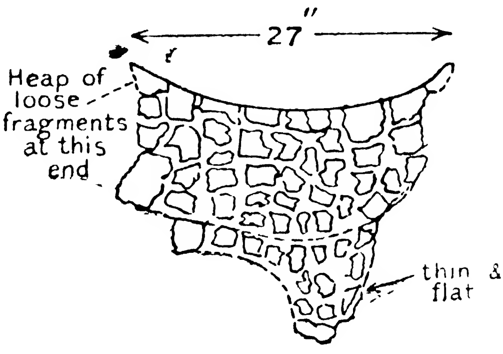


FIG. 2. Disintegrated portion of a bone, possibly a scapula, from Kallamedu bone-bed.

Of the remaining bones three were so fragmentary as to be unidentifiable, but they appeared to be parts of limb-bones. The others were certainly limb-bones. One was originally at least 50 inches long, another 42 inches in length. A length of 36 inches was left of another shattered bone. The last one was a massive limb-bone, destroyed by surface erosion, with fibrous gypsum adhering to parts of its surface.

From the above description it will be seen that the remains belong to one or more gigantic animals. From their shape, size and geological age it is clear that they are dinosaurian. They have the massive and solid character of sauropodous bones; some of the smaller are possibly stegosaurian. None of the bones found is theropodous, though Blanford's discovery of a megalosaurian tooth shows that theropods also lived in this region contemporaneously.[1]

The only Indian genus of dinosaurs, described up to the present time, which attained the dimensions of the Kallamedu reptiles is *Titanosaurus*. The type of the Indian genus (*T. indicus*) comes from Jubbulpore from a Cretaceous horizon which seems to be lower

[1] The presence of Megalosaurids in this area has been confirmed by material recently described by C. R. Narayan Rao and B. R. Seshachar. See the addendum to this paper.

than the Kallamedu deposit,[1] but the genus is also recorded from the highest beds of the Cretaceous system in Patagonia, in France and in Transylvania. It is just possible, therefore, that the Kallamedu bones belong to a Titanosaurid, but their condition is so poor that they cannot be even generically described.

The horizon of the ossiferous sands of Kallamedu can be closely fixed on stratigraphical and palæontological evidence. The Ariyalur group, the highest of Blanford's three groups, is of Upper Cretaceous age, and Blanford subdivided this group into three sub-groups,—a lower (fossiliferous), a middle (almost unfossiliferous), and an upper (fossiliferous) sub-group. The 'bone-bed' of Kallamedu lies near the base of his middle sub-group. Now, the beds at and near Ariyalur itself, in the lower sub-group, are of Upper Senonian and Mæstrichtian age, and there at Sendurai (Sainthorav) and Ninniyur, in the upper sub-group, are Danian. The dinosaurian remains that lie between the two belong therefore to a Mæstrichtian horizon.

The stratigraphical position of the bone-bed in the Ariyalur group is shown in more detail in figure 3. The beds dip very gently to the north or north-east at an angle of usually 2 or 3 degrees, the dip apparently rarely exceeding 5 degrees, and as the country rises from Ariyalur to Kallamedu there is an ascending sequence of the strata. The sands and sandy clays near Ariyalur, which lie some distance above the base of the Ariyalur group, yield the Upper Senonian and Mæstrichtian fauna shown in the fossil list III (*c*) and (*d*) on page 340. Sands with some sandstone bands continue in upward succession up to about 1½ miles north-east of Ariyalur, where, on the Ottakovil road, I found a new fossiliferous locality. The exposure there consists of soft sands (in which I found no fossils) overlain by clayey sand from which I collected about 200 echinoids in half an hour. Only one form is present, a new species of *Cyrtoma* (*Stigmatopygus*) which in shape and proportions closely resembles according to Prof. H. L. Hawkins who has examined the specimens, *Cassidulus planatas* Forbes from the Utatur beds of Moraviatur; and it is associated with many fragments of *Inoceramus* and an occasional gasteropod. More sands follow, and then a bed of sandy pisolite, full of valves of *Ostræa vesicularis*, make a flat tract of uncultivated country. This oyster bed, which is three feet thick in one place

[1] For a discussion of the age of the strata containing *Titanosaurus indicus* and *T. blanfordi* see Matley. *Rec. Geol. Surv. Ind.*, LIII, pp. 157 162 (1921).

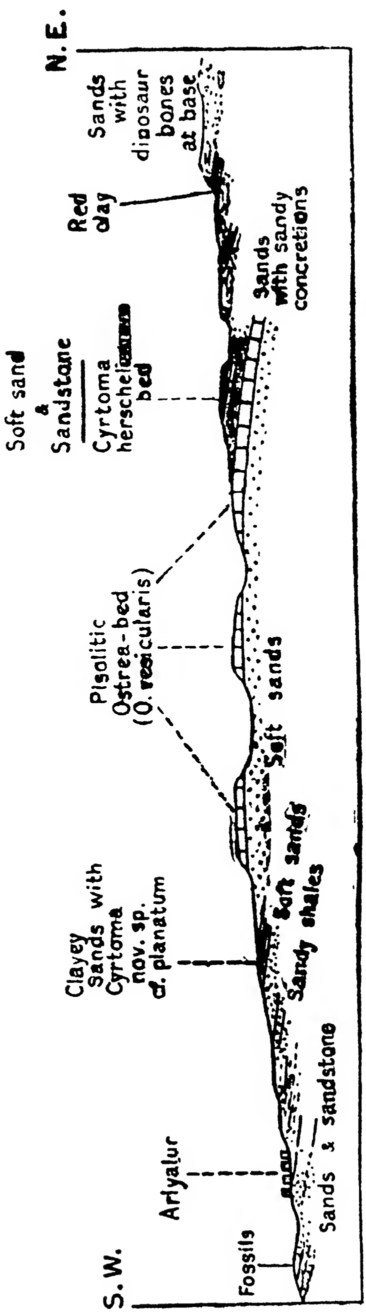


FIG. 3. Section from Ariyalur to Kallamedu bone-bed.

where I measured it, extends for $2\frac{1}{2}$ miles in a N. E. direction towards Ottakovil where it appears to be covered by higher beds. Blanford (*op. cit.*, p. 135) noted the abundance of a "large species of *Gryphæa*" in this district "scattered over the surface," but did not apparently recognise that it formed a persistent bed.

The strata overlying the *Ostræa* bed include the sandy and shaly beds east of Ottakovil where Blanford found (*op. cit.*, p. 135) "one of the richest fossil localities of the formation." The cephalopoda collected by him from these beds are of Mæstrichtian age. My own collection consists only of *Radiolites* sp. and *Ostræa ungulata*, as we had no time to search for the highly fossiliferous band, but Mr. Mukerjee found half a mile north of Ottakovil village an exposure of soft buff sand and sandstone extremely rich in echinoids belonging to a larger species than that found in the echinoid bed nearer Ariyalur. Several hundreds could have been collected at this exposure in an hour or two. The species is generally known as *Stigmatopygus elatus* Stol., but Prof. H. L. Hawkins, who has kindly studied my specimens, tells me that it has been described earlier (1840) by McClelland as *Cyrtoma herschelianum*. The geological position of this echinoid bed is probably a little lower than Blanford's cephalopod bed mentioned above. Sandy strata continue above the fossiliferous horizon until the red clay band is reached on which the dinosaurian bed lies. About two miles further on comes the fossiliferous Danian zone of Sendurai and Ninniyur, which I have not been able to visit.

During our search for dinosaurian bones around Kallamedu we made an interesting discovery of fossilised mammalian remains. We picked up a number of teeth and pieces of jaws of *Bos* (or *Buffelus*) and *Equus*, lying in and around the Kallamedu Nala, which differed from the remains of domesticated animals (which also are found) by being heavy and decidedly mineralised. I brought some of them to Calcutta and they are now in the collection of the Geological Survey. Dr. G. E. Pilgrim thinks they may have been derived from the Cuddalore Sandstone, which he regards as of Pliocene age. There is no doubt that the Cuddalore Sandstone once overlay this area, but Blanford's map shows no outlier in the drainage basin of the Kallamedu Nala. The fossils therefore suggest that either a small outlier has not been mapped or the denudation of one has recently been completed. They also suggest that the mammalian horizon is at the base of that sandstone.

IV.—VERTEBRATE REMAINS IN THE UTATUR GROUP.

In Blanford's memoir there is a reference to a supposed discovery of dinosaurian remains in the Utatur beds by Adolphe Schlagintweit in 1856. The passage reads as follows:—

> 'The late Mr. Adolphe Schlagintweit also paid a brief visit to the known localities of the Cretaceous rocks in the early part of 1856, and published a brief notice of his observations, which was reprinted in the 2nd number of the Journal of the Asiatic Society, Bengal, for 1857 (Vol. XXVI, page 109). Except the important discovery of the remains of a gigantic Saurian, supposed to be an *Iguanodon*, near Ootatoor, there is but little referring to the Cretaceous rocks in Mr. Schlagintweit's paper that had not been noticed by previous observers.' (*op. cit.*, p. 9).

The paper quoted by Blanford, however, contains not the slightest reference to the alleged discovery, nor can I find any allusion to it in any other contemporary publication. As it seemed unlikely that Blanford would have made his statement without some foundation I wrote on the subject to Mr. T. H. D. LaTouche who after enquiries ascertained that A. Schlagintweit's journals are preserved in the State Library at Munich, and obtained, by the courtesy of Prof. Dr. Leidinger, a copy of the explorer's manuscript field-notes relating to his visit to Utatur and neighbourhood in March 1856. They show that he found a large bone at Garudamangalam in a soft yellowish sandy bed containing ammonites, close to the outcrop of the hard shelly limestone known as 'Trichinopoly marble.' This bone, the only one found, was a piece of a long bone but it had no special characteristics and was unidentifiable. No dimensions are given. He makes no mention of Iguanodon, or even that the bone is reptilian. The supposed discovery of Iguanodon in India must therefore be disregarded. Blanford himself makes no further allusion to it, and his only mention of vertebrates in the Utatur group is on page 78 of his memoir, where he says that their remains are 'very scarce, the vertebræ and teeth of a fish (a shark) and a few bones of doubtful nature being the only instances of their occurrence.' The Utatur area was searched later for fossils by R. Bruce Foote, who in his "Rough Notes"[1] records the discovery of large vertebræ of Ichthyosaurus (afterwards described by Lydekker) and sharks' vertebræ and teeth, but he found no other reptilian remains.

[1] *Rec. Geol. Surv. Ind.*, XII, pp. 159-162 (1879).

During our visit to Utatur and neighbourhood, however, we discovered a large number of reptilian remains at a locality half a mile east of Neykkulam (Naicolum). They occurred in black soil (regur) overlying buff sand and soft sandstone of Cenomanian age and consisted of about 650 fragments of dermal armour accompanied by a few spine-like objects and some bones. All the specimens were collected from a tiny area not more than a square yard in extent and were found close to the surface and down to a depth of 12 inches. Each was coated with a thick incrustation of carbonate of lime. The scutes and spines appeared to represent part of the armour of a Stegosaurian, and they were described as such in a short preliminary note read to the British Association at Southampton in August 1925,[1] but the incrustation has since been removed from the material and further examination shows that some of the small bones are chelonian and that many of the 'scutes' may be smashed fragments of a carapace. There are difficulties in accepting the whole of the material, especially the spine-like objects, as chelonian, but pending the completion of the study of these bones it will be better to regard as cancelled the statement that they are dinosaurian.

V.—CONCLUDING REMARKS.

It will be seen from the above account that at least two groups of dinosaurs survived in Southern India up to almost the close of Cretaceous times. The Mæstrichtian beds of the Ariyalur group of the Trichinopoly district contain the remains not only (as was previously known) of carnivorous saurischia (Megalosaurids) but also of gigantic sauropoda, possibly Titanosaurids. There is a possibility that dinosaurian remains occur also in the Utatur group.

It is also recorded that fossil teeth and portions of jaws of *Bos* (or *Buffelus*) and *Equus* occur in the Ariyalur area and have probably been derived from the Cuddalore Sandstone.

In conclusion, I desire to express my grateful thanks to the staff of the Geological Department of the British Museum (Natural History) for identifying the invertebrate fossils recorded in this paper, and to Prof. H. L. Hawkins for examining the echinoids, which appear to be of limited vertical range and may define two palæontological zones.

---

[1] Rep. Brit Assoc. for 1925 (1926), p. 314.

VI.—ADDENDUM.

Since the above paper was written my attention has been called to two papers published in the Half-Yearly Journal of the Mysore University (Vol. I, No. 2 for July 1927),[1] from which I learn that the Ariyalur area has been recently visited by the geology students of the University, under the direction of Prof. P. Sampat Iyengar, and also by the zoology students. These two parties have been fortunate in finding a number of dinosaurian bones, including a vertebra, ilium, scapula, coracoid, head of a humerus, a tooth with a portion of the dentary, and limb bones mostly in a broken condition. This discovery is of importance as it is the first time that Southern India has yielded identifiable remains of dinosaurs. In the preliminary account of them given by the authors the tentative conclusion is arrived at that "the fossils must belong to a dinosaur reptile hitherto undescribed." From their account and figures it is clear that a theropodous dinosaur is represented in the collection, and sauropodous or stegosaurian bones are probably also present.

Owing to the construction of a new railway line from Trichinopoly Junction to Villupuram, the Ariyalur area has become much more easily accessible to geological investigation than it was at the time of my visit. It is to be hoped, therefore, that more geological visits will be paid to this interesting area, and that any further bones discovered will be carefully preserved and submitted for scientific examination.

---

[1] C. R. Narayan Rao and B. R. Seshachar. 'A Short Note on Certain Fossils taken in the Ariyalur Area (S. India).' pp. 144-152; and L. Rama Rao 'Notes on the Upper Cretaceous Rocks near Ariyalur, S. India,' pp. 153-7.

SOME ORBITOLINÆ FROM TIBET. BY G. DE P. COTTER, SC.D., F.G.S., M.INST.M.M., *Superintendent, Geological Survey of India.* (With Plates 27 and 28.)

The late Sir Henry Hayden, during his last visit to Tibet in the year 1922, collected several specimens of *Orbitolina* limestone from north of Lhasa, and from the region of the Great Lakes about 200 miles W.N.W. of Lhasa. These specimens were stored in the Geological Survey Office, Calcutta, and registered under the numbers K. 21/530, K. 21/531, and K. 21/536. A preliminary examination of Sir Henry Hayden's collection including many other specimens from different horizons was made by Dr. J. Coggin Brown in 1923, who recognised several upper Palæozoic, probably Permo-Carboniferous species, one doubtful Jurassic ammonite, and the orbitolines, which last are of Cretaceous age. The specimens of *Orbitolina*, which come from three distinct localities, were handed to me by Sir Edwin Pascoe in 1928 for description. I give the results of my examination below. The localities of the specimens are as follows :—

K. 21/530. South foot of Khan-sang La, N.E. end of Kya-ring Tso. In the map accompanying Hayden and Cosson's book, "Sport and Travel in the Highlands of Tibet", the Kya-ring Tso is shown as a long narrow lake, some 40 miles long by 7 or 8 miles wide, and extending in a W.N.W.—E.S.E. direction. There is a Kam-sang La marked about 18 miles N. of the E.S.E. end of the lake, and another Kam-sang La close to its W.N.W. end. It is probable that the latter locality is the one meant and that the entry N.E. in our register is a *lapsus* for N.W.

K. 21/531. Kyatsok. This is at the N.W. end of the Kya-ring Tso in lat. 31° 35′; long. 87° 50′.

K. 21/536. Lhundub Dzong, about 17 miles north of Lhasa; lat. 30° 35′; long. 91° 15′.

The last mentioned locality is just outside the area geologically mapped by Sir Henry Hayden in 1904 (11).[1]

The age of the *Orbitolina* limestone must be estimated on the evidence of the fossils themselves, since there are no geological notes

[1] The numbers in brackets refer to the references quoted in the bibliography at the end of this paper.

available whereby the age of the limestone could be fixed through its stratigraphical position.

The best preserved specimens of *Orbitolina* come from Kyatsok (K. 21/531). From this locality, we have in the Museum three tubes filled with *Orbitolina* and one specimen of limestone made up of crowded masses of *Orbitolina* cemented together in a calcareous matrix.

As it was impossible to separate the orbitolines from the matrix in this single specimen of limestone available from Kyatsok, my colleague Dr. W. A. K. Christie estimated the silica in some of the orbitolines from one of the three tubes above mentioned, and also in the single specimen of *Orbitolina* limestone. He found 5·26 per cent. of silica in the orbitolines and 2·91 per cent. of silica in the *Orbitolina* limestone. These results show that the silica present is mainly confined to the orbitolines, and generally agree with the previous descriptions of *Orbitolina*, which is described by Martin (3), Douvillé (5), and others as a sub-arenaceous genus of the *Foraminifera* and is usually rich in silica.

The orbitolines from Tibet are apparently a single species represented by both megalospheric and microspheric forms. There are two types, a small conical, and a larger flatter disc-shaped one, and some of intermediate shape. While the larger flatter forms appear to be invariably microspheric, the remainder, including the smaller but flattish forms and the conical specimens are not invariably megalospheric. There is every gradation in shape between the extremely conical and extremely flat specimens. Amongst the conical forms I have found a few specimens in which the megalospheric central cells are preserved; these specimens measure from 3·5 to 4 mm. in diameter. In the microscope section, shown on Plate V, figure 12, a rather flat megalospheric individual is shown. The megalospheric forms therefore tend to be, but are not always markedly conical in shape; they are considerably smaller than the microspheric adult forms.

H. Douvillé, (6, p. 568) who was the first to study the relationships of the megalospheric and microspheric forms, states that the two forms almost always differ, the former being conical, and the latter discoid; thus he shows that *O. conoidea* and *O. discoidea* form a couple representing forms A and B of a single species. In regard to the present Tibetan species, I regard this statement as broadly correct but not rigidly so, since some of the megalospheric forms are,

as has been seen, rather flat. It may be assumed however that the larger flatter forms are microspheric. The Tibetan species of *Orbitolina* differ, so far as I am able to ascertain, from any other previously described species, and may be given a new specific name *O. tibetica.* The description is as follows :—

ORBITOLINA TIBETICA sp. nov.

Description.—Test in larger forms always discoidal and measuring up to 10 mm. in diameter, with a thickness of 2 mm. or less; the upper surface has a central boss, which spreads out into a saucer-shaped disc. The lower surface is convex near the margins and hollowed out in the central region. The margin is fairly sharp-edged, and not fully rounded as in *O. bulgarica.* There is every gradation in shape from the flat or discoidal forms to the conical forms; in the latter, which are always small, the upper surface is a fairly perfect cone, with an angle which may be as acute as 90°. The under surface of the conical forms is usually hollowed out and rarely flat or gently convex as in *O. conoidea* (see 5, Plate XVII, figure 2). In this feature it differs from *O. paronai* and *O. bulgarica* as figured by Prever, (14, Plate I, figures 4 to 11), but recalls the form *O. bulgarica var. Janenschi* from East Africa described by W. O. Dietrich (10, Plate IV, figures 4 and 5). The smaller conical forms vary from 5 mm. to 2 mm. in diameter with a height of from 2·5 to under 2 mm. In the better preserved forms, the upper surface of the test is seen to be composed of a thin lamina probably imperforate, supported by a mesh structure, the *r'seau poutrellaire* of H. Douvillé (5, p. 658). Immediately underneath this are the rectangular cells arranged in concentric circles, and separated by circular lamellæ, which are from ·053 to ·059 mm. distant from one another. Good vertical sections show the sub-divided "cortical" cells noted by L. M. Davies, (7, p. 238 and Pl. XVII, figure 10) which form the superstructure of the large rectangular cells, and lie in the region of the *réseau poutrellaire.* We may also compare Martin's figure, (3, Plate XXIV, figure 11), in which septa of the 3rd order are shown, sub-dividing the superstructure of the rectangular cells. It may be noted that in Martin's paper, the undersurface of the *Orbitolina* is spoken of as the upper surface, and *vice versâ.*

The rectangular cells are rectangular only in the neighbourhood of the surface; in depth they become irregularly shaped and tend to be triangular (see Plate 27, figure 2). A transverse section perpendi-

cular to the axis and near the base of the test shows the zig-zag radial or irregular (Plate 27, figure 4) disposition of the septa, which may be compared with figs. 2, 3 and 4 in Plate XVII accompanying H. Douvillé's paper on the structure of the Orbitolines (5). In comparison with the species of *Orbitolina* figured by H. Douvillé, it may be observed that the Tibetan species are of a very fine texture, like that of *O. concava*, with very much finer and more close-set concentric lamellæ.

Both in horizontal and vertical sections the tests show fragments of foreign material which has been incorporated therein. K. Martin, (3) describes in the *Orbitolinæ* from Borneo certain "fremdkorperchen" or small foreign bodies mainly of quartz, but occasionally of felspar. In my specimens from Tibet, which are more calcareous than is commonly the case in this group, the foreign material appears to be mainly calcite, and is in origin probably derived from fragments of comminuted shells.

Relations and differences.—Certain *Orbitolinæ* from South Western Tibet were described by H. Douvillé in Sven Hedin's great work on Tibet (15, Vol. V, p. 145 and Plates IX, X, XI) from Lower Cretaceous rocks. Amongst these a couple is described, the megalospheric form of which is identified with *O. bulgarica,* and the discoidal form is compared with *O. discoidea.* In Douvillé's Plate IX, figure 3, this *O.* cf. *discoidea* appears to have concentric lamellæ set at about ·076 mm. apart, which indicates a species with considerably larger rectangular cells than in *O. tibetica.* Moreover Douvillé speaks of a spiral arrangement of cells near the megalosphere of a megalospheric individual (*O. bulgarica*). I see no trace of any such spiral arrangement in my specimens, which therefore differ both in this respect and in the size of the rectangular cells from those described by Douvillé. It is necessary therefore to regard my specimens as specifically quite distinct from those described by H. Douvillé.

From the European *O. discoidea* Gras and *O. conoidea* Gras, which may be regarded as a couple constituting forms A and B of a single species, the Tibetan form is distinguished by the fine and close-set concentric lamellæ, which in *O. discoidea-conoidea* are from ·08 to ·09 mm. distant. In the Borneo specimens described by Fritsch (2) under the generic name of *Patellina*, (*P. scutum* and *P. trochus*), which may, as H. Yabe and S. Hanzawa (8) have pointed out, be regarded as a couple forming one species *O. scutum-trochus*, the texture is coarser, the test more arenaceous, and the

concentric lamellæ are distant ·08 mm. The nearest relation to the Tibetan species is *O shikokuensis* Yabe and Hanzawa; in this species the concentric lamellæ are ·056 mm. distant, that is, about the same distance as in our species. In both species the texture is extremely fine, but the Japanese species does not appear to exceed 4 mm. in diameter, while the Tibetan form attains 10 mm. Another species which closely resembles the Tibetan form is that described under the name *O. bulgarica* var. *Janenschi* by W. O. Dietrich, (10) from East Africa. Dietrich omits to give any microphotographs whereby the distance of the concentric lamellæ can be calculated, and I cannot therefore be certain whether the two species are distinct or the same.

An account of certain orbitolines from Shushal near Leh in Ladakh is given by E. Fossa Mancini in the report of the Filippi Expedition (16, p. 189). In this two species *O. pileus* and *O. parma* are described; in the description of the latter species, the concentric lamellæ are stated to be 10 mm. distant from one another; the species is therefore quite distinct from the one now described.

Horizon and Age.—It is not possible from stratigraphical evidence to fix the age of the *Orbitolina*. The species is apparently a new one, although resembling closely *O. shikokuensis* and the East African species which Dietrich regards as a variety of *O. bulgarica*. In Japan, the beds from which *O. shikokuensis* comes lie at the base of a *Trigonia*-bearing sandstone, and are apparently of Hauterivian age. The East African species appear to be of Urgonian age. Douvillé (15, Vol. V, p. 147) places the Tibetan forms which he identifies with *O. bulgarica* in the Barremian. *Orbitolina* ranges in Europe (6) and in Japan (8) from the Lower Cretaceous to the Cenomanian. But if the orbitolines come from approximately the same horizon as those described by H. Douvillé from Tibet, it is possible that the Lower Cretaceous is represented. A horizon such as the Hauterivian or Barremian appears to be the most likely for these Orbitolines, but there can be no certainty about this until further work has been done in the field.

BIBLIOGRAPHY.

(1) CARTER, H. J. . . Further Observations on the Structure of Foraminifera, *Ann. and Mag. of Nat. Hist.*, 3rd ser., Vol. VIII, pp. 446-470 (1861).

(2) FRITSCH, K. VON . Einige Eocäne Foraminiferen von Borneo. *Palæontographica,* Suppl. III, Lief. I, pp. 139-146 (1875).

(3) MARTIN, K. . . Untersuchungen ueber den Bau von *Oribitolina; Samml. des Geol. Reichs-Mus. in Leiden,* Vol. IV (1884-1889), pp. 209-229.

(4) VERBEEK R. D. M. AND FENNEMA R. Description Géologique de Java et Madoura, (1896).

(5) DOUVILLÉ, H. . . Sur la Structure des Orbitolines, *Bull. Soc. Géol. France,* 4th ser., Vol. IV (1904), pp. 653-661.

(6) DOUVILLÉ, H. . . Les Orbitolines et leurs Enchainements, *Comptes Rendus des s'ances de l'Academie des Sciences,* Vol. 155 (1912), pp. 567-572.

(7) DAVIES, L. M. . . Remarks on Carter's Genus *Conulites* (*Dictyoconoides* Nuttall), *Rec. Geol. Surv. Ind.,* Vol. LIX, pp. 237-253 (1926).

(8) YABE, HISAKATSU, AND HANZAWA, SHOSHIRO. Geological Age of the *Orbitolina*-bearing rocks of Japan; *Sci. Rep. of the Tohoku Imp. Univ. Sendai, Japan,* 2nd ser. (Geology), Vol. IX, No. 1, pp. 13-20 (1926).

(9) DOUVILLÉ, H. . . La Forme Conique chez les Foraminifères, *Bull. Soc. Géol. France,* 4th ser., Vol. XXVI (1926), pp. 21-26.

(10) DIETRICH, W. O. . Zur Kenntniss der Urgogesteine in Südlichen Ostafrika nebst Beschreibung der darin Vorkommenden Orbitolinen; *Palæontographica,* Suppl. VII, ser. 2, pt. 1, pp. 25-40 (1925).

(11) HAYDEN, H. H. . Geology of the Provinces of Tsang and U in Central Tibet. *Mem. Geol. Surv. Ind.,* XXXVI, p. 122, sqq. (1907).

(12) DOUVILLÉ, H. . . Le Crétacé et l'Eocène du Tibet Central. *Pal. Indica*, N. S., Vol. V, Mem. III (1916).

(13) HAYDEN, SIR H. H. AND COSSON C. Sport and Travel in the Highlands of Tibet (1927).

(14) PARONA, C. F., CREMA, C., AND PREVER, P. L. La Fauna Coralligena del Cretaceo dei Monti D'Ocre nell' Arbuzzo Aquilano. *Mem. alla Descr. della Carta Geologica d'Italia*, Vol. V, Roma 1909.

(15) SVEN HEDIN . . Southern Tibet; Vol. V. Petrographie und Geologie, by Prof. A. Henning, with an addendum, (pp. 145-147) on the Limestones with *Orbitolina* and *Radiolites* by Prof. H. Douvillé.

(16) FOSSA MANCINI, E., PARONA, C. F., AND STEFANINI, G. Fossili del Secondario e del Terziario, being series II, Vol. VI, of the Relazioni Scientifiche della Spedizione Italiana de Filippi nell' Himalaya, Caracorum, Turchestan Cinese; Bologna, 1913-1914.

EXPLANATION OF PLATES.

PLATE 27.

FIGS. 1 to 8.—*Orbitolina tibetica* n. sp., magnified 3·66 times. Figures 3 and 7 are flat forms; figure 4 is the most conical; figures 1, 2, 5, 6 and 8 are moderately conical forms. In figures 2, 4 and 6 the external ornamentation is well preserved.

FIGS. 9, 10.—*Orbitolina tibetica* n. sp.; discoidal forms showing concentric lamellæ and central boss. Magnified 18 times.

FIG. 11.—Vertical section through two specimens of *O. tibetica*, which are cemented together by calcareous matrix. Magnified 13 times.

FIG. 12.—Vertical section through a megalospheric form. Magnified 23 times.

NOTE.—The specimens figured in figures 1 to 1 1are from Kyatsok; that shown in figure 12 ·from Lhundub Dzong.

PLATE 28.

FIG. 1.—*Orbitolina tibetica* n. sp. Specimen etched with dilute HCl, to expose the concentric lamellæ. Magnified 34 times.

FIG. 2.—Horizontal section through another specimen in a latitude below the region of rectangular cells. In this the lower portions of the rectangular cells are seen to have roughly triangular or irregular outlines. Magnified 23 times.

FIG. 3.—Vertical section through a discoidal specimen of *O. tibetica* not traversing the central boss. Magnified 13 times.

FIG. 4.—Horizontal section through another specimen of *O. tibetica* at a lower latitude than that of fig. 2. Magnified 23 times.

FIG. 5.—Oblique section through a megalospheric form of a moderately conical type. Magnified 13 times.

NOTE.—All the specimens are from Kyatsok.

NOTE ON THE JOYA MAIR DOME FOLD, NEAR CHAKWAL, JHELUM DISTRICT, PUNJAB. BY D. N. WADIA, M.A., B.SC. (BOMBAY), F.G.S., F.R.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plate 29).

Area and location.

During the course of my survey of the Chakwal area, in the wide zone of Upper and Middle Siwalik strata along the S. E. flank of the Soan geosyncline, an anticline with a dome termination and steep pitch was mapped, which by nosing, one and a half miles south of Joya Mair village (33° 1′; 72° 45′), produces a type of fold commonly designated a "semi-dome," encompassing over ten square miles. This type of structure is very uncommon in this belt of broad sweeping flexures, and as it lies within an area of active petroleum prospecting, a brief note is here subjoined. If petroliferous beds exist in the area, they are probably within easier reach of the drill along the crest line of the Joya Mair dome fold than elsewhere in the Chakwal and adjoining parts, by reason of the fact, ascertained during the same survey, that the thick series of Murree sandstones, which intervene between the Siwaliks and the oil-generating Nummulitics, are cut out by an unconformity, which is clearly visible in all contiguous exposures of the latter series. Sixteen miles south-west of Chakwal, basal Siwaliks of the Kamlial horizon, containing *Mastodon* and derived nummulites, lie unconformably on a series of extensive dip-slopes of the Upper Nummulitics, while twelve miles south of Chakwal the unconformity becomes even more marked, for the Kamlials are found to rest there directly on the Lower Nummulitic limestones.[1]

Geological structure and relations.

The Joya Mair dome lies on a level, much dissected plateau, composed of Middle Siwalik rocks with a capping of alluvium, at the W.S.W. extremity of a long, symmetrical, gently-folded anticline, striking E.N.E. towards Padshahne. West of the village of Dhab a pronounced elevation of the axis of this fold takes place and brings to the surface an irregular elliptical core of the under-

[1] Director's General Report: *Rec. Geol. Surv., Ind.*, LX, p. 103, 1927.

lying Chinjis, consisting of bright, brick-red nodular clays, with soft sandstone intercalations. To the north, west and south of this core the fold expands, with quaquaversal dips of low inclination, varying from 25° to 5°, the dome termination of the fold having an observed radius of from 3-4 miles in these directions. The quaquaversal dips are seen clearly in the alluvium-covered exposures to the west, between Maingam and Bule and in the water-courses to the north and south of these villages. To the east the dome-fold passes into a single symmetrical anticline at Dhab, for the most part concealed under alluvium.

Rock-formations exposed.

The Chinjis are the oldest rocks exposed in the centre of the fold. Thickness of about 900 to 1,000 feet is exposed out of a total of 3,000 feet, the maximum thickness attained by the Chinjis in this part. The Kamlial stage, the next underlying stage, and the main sandstone formation of the Lower Siwaliks, must, therefore, be at least 2,000 feet below the crest line. The Chinjis are overlain by the grey soft sandstones, with brownish clay partings, comprising the Middle Siwalik series which constitutes nearly $\frac{5}{6}$ of the area of the dome. These in turn are succeeded, after a thickness of over 4,000 feet, by the Upper Siwalik clays and sandstones (sand-rock), along the north and west periphery of the dome, nearly $5\frac{1}{2}$ miles away from its central part. These various Siwalik stages show distinctly transitional passages, above and below, and hence the boundary lines separating them are to some extent conventional.

The crest of the dome-fold.

The crest of the elongated dome is defined by a rather steep, asymmetrical anticline which runs through the southern third part of the ellipse of Chinji rocks, following the main strike, but with many abrupt bends. At the west extremity, the anticlinal core has, for some hundred yards, a vertical dip, but further east the steepness diminishes and the narrow south limb has an inclination of 60°-70°, gradually diminishing to 10° on the S.S.E. flank. The opposite broader limb has an inclination of 40°-25° within the Chinji ellipse, gradually falling away to 10° and 5° to the north and north-west, along the periphery. This limb supports a small subsidiary syncline, pitching sharply to the west and hence carrying a rib of Middle Siwalik sandstones. This circumstance has produced a forking of the Chinji core at the north-west corner. The soft incompetent Chinji clay strata show a considerable amount of disturbance,

accompanied by frequent dip and strike discrepancies in this central axial belt of the fold.

Nearly half the area of the dome, the eastern half, is covered by thick sub-Recent alluvium with scarcely any exposures, between Joya Mair and Dhab. The central and western part of the dome is all rocky and is intersected across the strike by the two branches of the Sauj-Kas stream and their numerous deep tributary ravines meandering through the plateau and producing the intricately cut *khuddera* type of ground, which makes geological investigation somewhat difficult and protracted.

Faults.

Besides some minor dislocations of strata in the region of tight plication along the axis, the main area of the Joya Mair dome is free from faulting of any magnitude. One strike-fault, however, of inconsiderable throw, occurs on its S. W. flank in the Middle Siwalik sandstone cover. It starts just N. W. of Dhakku and proceeds due west for three miles, when it disappears under the alluvium and probably dies out. On the north side of the fracture, Middle Siwalik beds dipping 40° to the S. S. E. are thrown against beds dipping S. S. W. at 10° of the same stage, but probably newer.

Economic prospects of oil at Joya Mair.

Whether the existence of a productive oil-bearing horizon in the southern part of the Potwar be a fact yet proven or not, the structure represented by the Joya Mair dome is of a type favourable for the underground storage of oil on a promising scale. This is a type of structure but rarely met with in the Potwar Siwalik terrain east of the Khaur and Dhulian oil-fields. One further favourable circumstance is the probable absence at Joya Mair of the entire Murree series (or the greater part of it) from the sequence of deposits overlying the Eocene Nummulitic limestones and associated group of rocks which constitute the known source of oil in the Punjab. The existence of this unconformity brings the Nummulitic horizon considerably nearer the apex of the fold than in the areas situated in the more northern parts of the Potwar, where the Murrees are known to occur in great force. The fact, however, that in some parts of Chakwal the absence of the Murrees is also accompanied by an absence of the Upper Nummulitics (the Chharat stage, which according to some authorities is the main oil-producing stage in the Punjab Eocene) to some extent discounts the favourable nature of this factor. More detailed work, however, and mapping on a larger

scale than has been possible in a preliminary one-inch-to-the-mile survey, will doubtless be necessary, before accurate estimates regarding depth and other factors can be arrived at.

Thickness and composition of cover.

The lithological constitution as well the approximate thickness of the sedimentary cover on the Nummulitics, as could be deduced from my examination of the sections laid bare to the south of Chakwal, where the Nummulitic-Siwalik unconformity is observed without any doubt, may be represented in the following table :—

Middle Siwalik series: (4,000 feet). Thick-bedded, grey, soft sandstones and sand-rock with grey, orange, or drab shales; pseudo-conglomeratic beds and some pebbly beds at the base. Proportion of sandstone to shale—5 : 1.

Chinji Stage : (3,000 feet).—Upper beds. Thick bright red clays and shales nodular at times, with subordinate blue-grey, soft sandstones and pseudoconglomerates.

Lower beds. Red and purple nodular shale and clays with fairly hard sandstones.

Fossils—*Mastodon*, *Antelopes*, other ungulate bones.

Proportion of sandstone to shale—1 : 4.

Kamlial Stage : (1,400-1,700 feet).—Dark-coloured, hard, massive sandstones red and purple shales full of calcareous concretions and many clay pseudoconglomerate beds. Fossils—*Mastodon* and *Chelonian* bones. Proportion of sandstone to shale—5 or 4 : 1.

———————— Unconformity.

Nummulite shale (Upper Nummulitic Stage).

These figures give roughly a depth of 3,400 feet for the Nummulitics from the surface rocks at the crest of the dome.

It should be observed here that the Tertiary fluviatile sediments of the Potwar basin increase in thickness northwards towards the foot of the Himalaya. Hence the Murree series, absent in the Salt Range sections south of Chakwal, is likely to come in and increase in thickness progressively northwards (in the Khaur oil-field 40 miles north of the Salt Range about 300 feet of the Upper Murrees are encountered), while the thickness of the various Siwalik stages, observed in the same sections, are also likely to be proportionately greater to the north. For this reason in the figures for thicknesses of the various stages given here an allowance has been made for this condition. In the figure for the Kamlials about 100-150 feet of the Murrees (indistinguishable in lithology from the base of the latter stage) are allowed for.

It must be stated that throughout the area of the Joya Mair dome-fold a careful search has failed to reveal any gas or oil seepages or other indications of oil. In the springs and waters running in the central, deeply dissected parts of adjacent anticlinal valleys, also, no traces of oil have been detected.

No surface indications of oil.

The above note has been written on a realisation of the truth of the saying that "not all of the structures bear oil, but almost all of the oil-pools are on structures."

AN OCCURRENCE OF ALLOPHANE AT TIKAK, ASSAM. BY A. L. COULSON, M.SC. (MELB.), D.I.C. (LOND.), F.G.S., *Assistant Superintendent, Geological Survey of India.*

Occurrence.

The material in question occurs as streaks and pockets in the 20-foot coal seam in the Assam Railways and Trading Company's quarries at Tikak, Assam. It was sent to my colleague, Dr. C. S. Fox, by Mr. G. E. Hines of the above company, of Margherita, Assam, and subsequently forwarded to this department for identification.

Physical properties.

The material, which is registered as M 982 in the collections of the Geological Survey of India, closely resembles in outward aspect a fossil resin. It is amorphous and occurs in mammillary growths, at times definitely stalactitic in nature. Its fracture is conchoidal; it is very brittle. Its hardness is 3.

Two determinations of its specific gravity by the specific gravity bottle gave 1·93 and 2·00. A further determination by means of the Westphal balance, using solutions of thallium formate and thallium malonate, showed that the lightest of six small pieces had a specific gravity of 1·97 whilst that of the heaviest was 2·13. Thus the average specific gravity is about 2·0.

The lustre of the material is vitreous to sub-resinous. Its colour varies through shades of orange-yellow (Ridgway,[1] III, 17, f—m); its streak is white.

Microscopic characters.

The material is transparent in thin section; it is isotropic. Three determinations of the refractive index for sodium light by means of a mixture of cedarwood and clove oils resulted as follows:—

1·484 ± ·002 at 33·5° C.

1·489 ± ·002 at 26° C.

1·486 ± ·002 at 30° C.

[1] "Color Standards and Color Nomenclature." Washington, 1921.

Larsen[1] gives the refractive index of allophane as 1·47 ± and 1·49. The refractive indices of specimens of allophane in the Indian Museum were determined as under :—

Specimen . . .	M. 2092. . .	M. 2091. . .	K. 245.
Refractive Index .	1·476 ± ·001	1·482 ± ·002. .	1·482 ± ·002
Temperature . .	31°C. . .	31° C. . .	31° C.

M 2092. White allophane, Woolwich, Kent, England.

M 2091 (B 1040). Green allophane, Grossard, Salsburg, Alps.

K 245. Blue allophane, Surkhpetao, near Dehtang, Ghorband (35° 5′: 68° 50′), Afghanistan.

Pyrognostics.

The material under consideration gives a blue colour with cobalt solution. Heated in a closed tube, it gives off abundant water which is acidic to litmus paper. Between 100°C. and 150° C., the colour of the substance changes to black and the oxidation of this black material necessitates prolonged heating.

Composition.

A picked sample of the material was analysed in the laboratory of this department by Mr. P. C. Roy, the result being given in Column I of the following table. The ash, which amounted to 57·99 per cent., was also analysed by Mr. Roy with the result given in Column II.

Allophane.	I.	Ash.	II.
Moisture	18·29	..	..
H	2·44	SiO_2 . .	32·44
C	4·77	Al_2O_3 . .	67·42
N	0·20	Fe_2O_3 . .	0·25
S	0·63	CaO . .	trace
O (by diffce.) . . .	15·68	MgO . .	0·25
Ash	57·99	..	..
TOTAL .	100·00	TOTAL .	100·36

[1] E. S. Larsen. "The Microscopical Determination of the Non-Opaque Minerals." *Bull. 679, U. S. Geol. Surv.*, 1921, pp. 172, 3.

In the following table, Column III shows the complete analysis obtained by recalculating the figures for the constituents of the ash given above so as to total 57·99 per cent. Column IV shows the results of another analysis of the material under examination, this having been done by Mahadeo Ram in the laboratory of this department.

	III.	IV.
$Si\,O_2$	18·75	18·99
$Al_2\,O_3$	38·96	35·99
$Fe_2\,O_3$	0·14	0·16
$Ca\,O$	trace	trace.
$Mg\,O$	0·14	1·13
$H_2\,O$—110°	18·29	18·29
$H_2\,O$+110°	....	19·05
H	2·44	....
C	4·77	....
N	0·20	....
S	0·63	0·65
O (by diffce.)	15·68	....
Loss on ignition (less $S+H_2O$)	....	4·11
TOTAL	100·00	98·37

The total percentage of water in Analysis III may be calculated as follows :—0·63 per cent. sulphur requires 0·94 per cent. oxygen to form SO_3, thus leaving 14·74 per cent. of oxygen. Assuming that all this 14·74 per cent. of oxygen is combined with hydrogen as water,[1] the percentage of combined water will then be 16·58 ; thus the total percentage of water in Analysis III is 34·87.

[1] A certain percentage of the oxygen will be combined with carbon and hydrogen as coal ; quite possibly a little carbonate might be present.

Molecular ratios.

Assuming the correctness of the above deductions, the molecular ratio for the oxides Al_2O_3 : SiO_2 : H_2O is found to be 0·38 : 0·31 : 1·94 or 1·2 : 1 : 6·3 in Analysis III. Mahadeo Ram's analysis, IV, gives a molecular ratio of Al_2O_3 : SiO_2 : H_2O as 0·35 : 0·32 : 2·07 or 1·1 : 1 : 6·5.

Allophane.

The composition of allophane is generally given as $Al_2O_3 . SiO_2 . 5H_2O$ though it is perhaps more correctly given as $Al_2O_3 . SiO_2 . \times H_2O$.[1] As Dana [2] notes, some analyses give 6 equivalents of water corresponding to SiO_2 22·2, Al_2O_3 37·8, H_2O 40·0=100·0. There thus appears to be no doubt that this Tikak material is allophane.

Previous occurrence in India.

According to Mallet [3] two specimens of allophane from the Deputy Commissioner of Simla, presumably, therefore, obtained in the Punjab Himalaya, were sent to the Indian Museum for determination; one of them was pale sky-blue in colour, the other partly green. No information was obtainable as to how or where they were found. I know of no other recorded occurrence in India.

---

[1] C. Hintze. "Handbuch der Mineralogie," Band II. 1897. p. 1829.
[2] "System of Mineralogy," 6th Edition, New York, 1904, p. 693.
[3] Manual of the Geology of India, IV, Mineralogy, Calcutta, 1887, p. 119.

MISCELLANEOUS NOTE.[1]

Australian Species of the Genus *Gisortia*.

Prof. A. Morley Davies wrote to me in December 1927 pointing out that the ages attributed to the various Australian species of *Gisortia* in E. Vredenburg's "Review of the Genus *Gisortia*" (*Palæonotologia Indica*, New Ser., Vol. VII, Mem. 3.) was not in agreement with modern opinion. The study of the distribution of such neogene foraminifera as *Lepidocyclina* and *Miogypsina* in the Australian deposits has led to a modification of the old views. In Mr. Vredenburg's memoir, the Australian *Gisortiæ* are in all cases but one placed in the Upper Eocene. The following table represents the views of Prof. Davies: this table has also been checked by Prof. F. Chapman, Commonwealth Palæontologist, National Museum, Melbourne, who notes that the species *G. eximia* Sowerby and *G. sphærodoma* Tate, are quite distinct from one another.

Table showing Revised Ages of Australian species of Gisortia.

Vredenburg's number.	Species.	Local formational name.	Approximate age.
10	*leptorhyncha* McCoy	Balcombian, Janjukian Kalimnan.	Aquitanian to Lower Pliocene.
11	*platyrhyncha* McCoy	Janjukian	Miocene.
12	*amygdalina* Tate	Janjukian	Miocene.
13	*platypyga* McCoy	Balc.-Janj.	Aquitanian and Miocene.
14	*consobrina* McCoy	Janjukian	Miocene.
18	*eximia* Sow	Balc.-Janj.	Aquitanian and Miocene.
	sphærodoma Tate	Balc.-Janj.	Aquitanian and Miocene.
19	*toxorhyncha* Tate	Balcombian	Aquitanian.
23	*gigas* McCoy	Balc.-Janj..	Aquitanian and Miocene.
24	*dorsata* Tate	Balc.-Janj.	Aquitanian and Miocene.
26	*gastroplax* McCoy.	Balcombian	Aquitanian.
27	*mulderi* Tate	Janjukian	Miocene.

G. DE. P. COTTER,

[1] This note has already appeared as a corrigendum slip to *Pal. Indica*, N. S., Vol. VII, Mem. No. 3.

INDEX TO RECORDS, VOLUME LXI.

H M. L[illegible], Photo

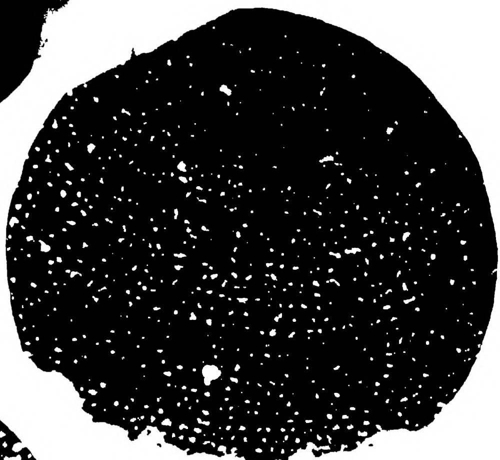
ERRATIC BLOCKS RESTING ON TRIASSIC LIMESTONE NEAR BURA

G S I Calcutta.

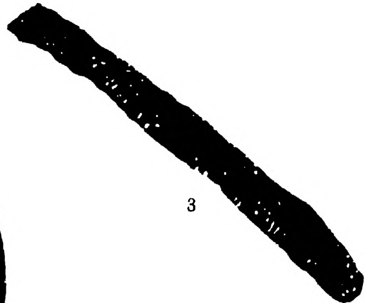
G. de P. Cotter, Photos *G. S. I. Calcutta*

ORBITOLINA TIBETICA *n. sp*

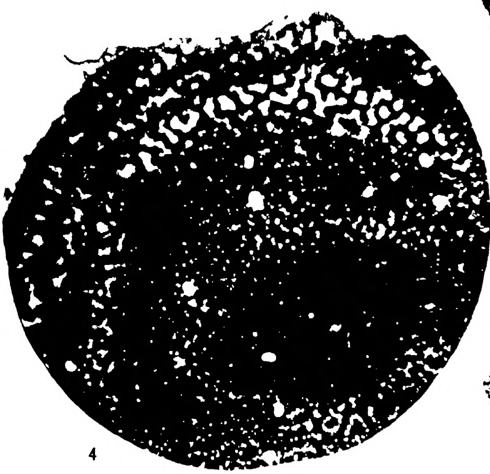
1



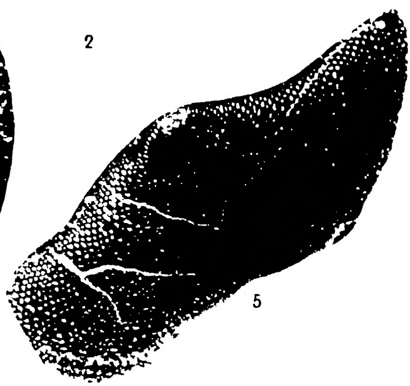
2



3



4



5

G. de P Cotter, Photo. *G S I. Calcutta*

ORBITOLINA TIBETICA *n sp*

Date of issue.	Date of issue.	Date of issue.
1/2/95		I/L

MGIPC—S5—38 AR/54—7-7-54—7,000.